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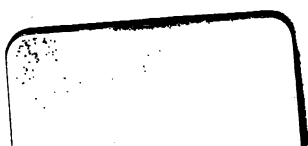
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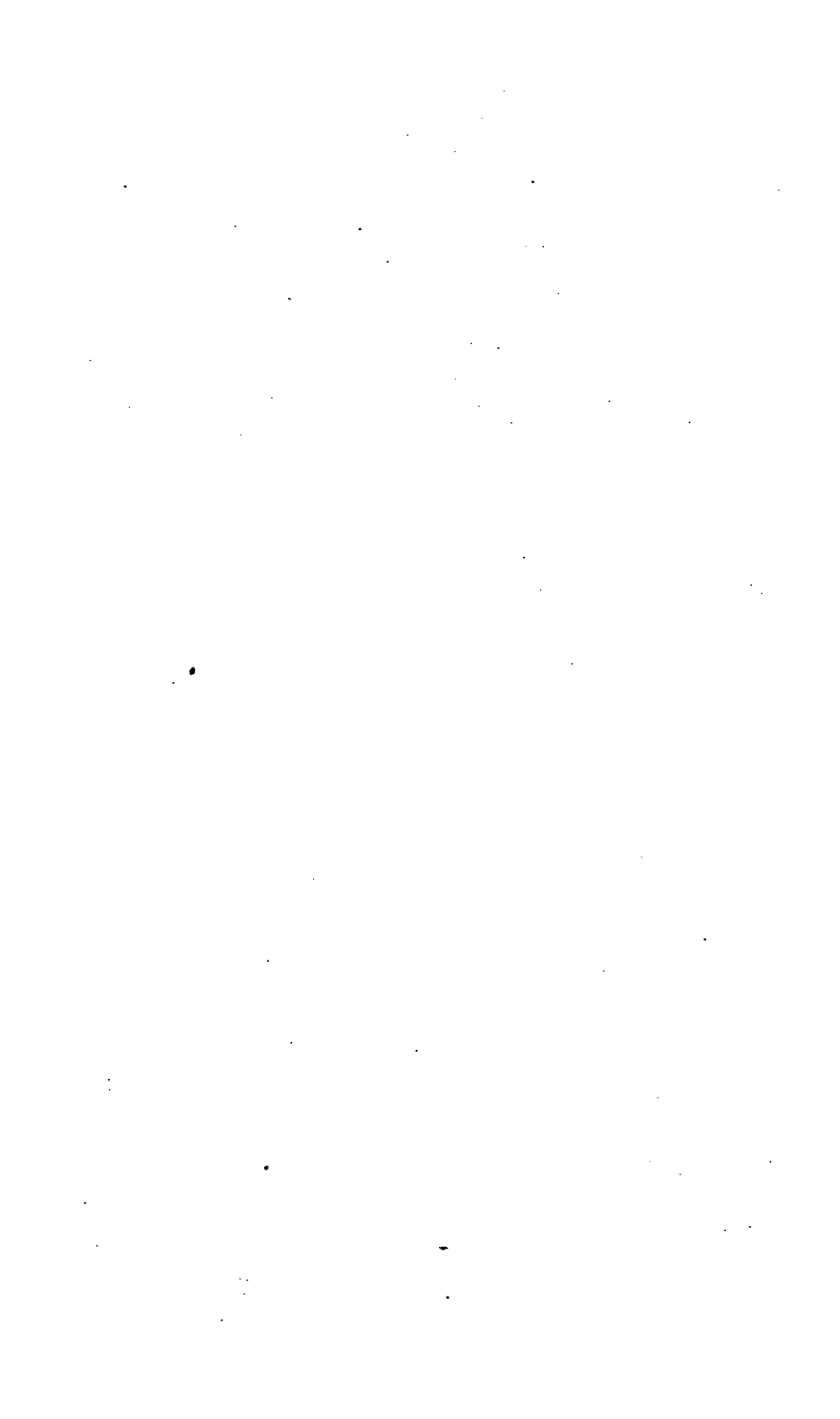
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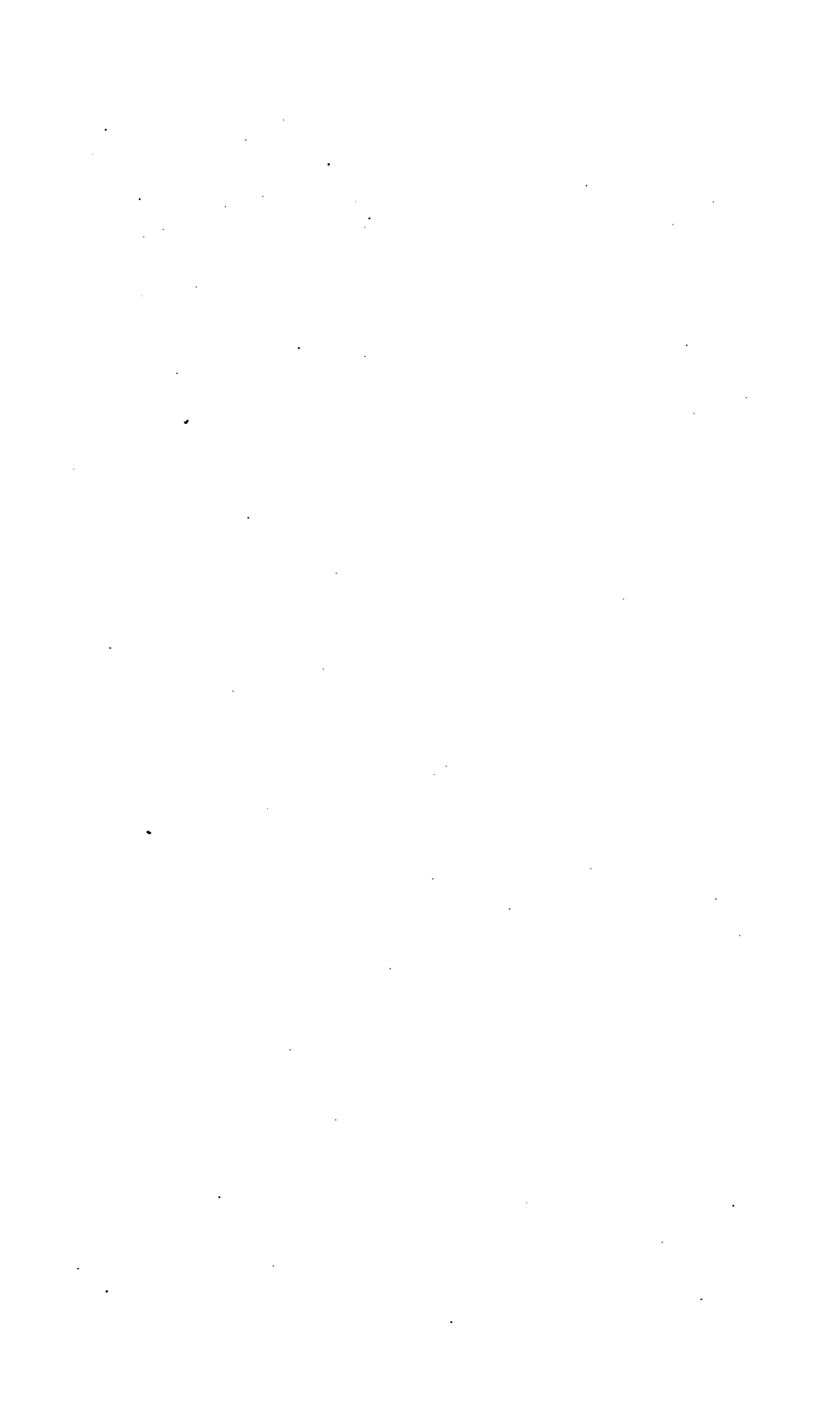
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CHEMISTRY

AS APPLIED TO

32

THE FINE ARTS.

BY

GEORGE H. BACHHOFFNER,

LECTURER ON CHEMISTRY.

QUÆRE ARTEM QUÆCUMQUE JUVANT; FUGE QUÆQUE REPUGNANT.
Du Fremoy.

LONDON:

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1837.

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P R E F A C E.

THE Author of the following pages having delivered several courses of lectures on the subject of Chemistry, as applied to the Fine Arts, it was suggested to him by several eminent members of the profession, that if the substance of these lectures were printed, it would form a useful book of reference for the artist.

With that view the following sheets have been published, which he trusts will meet the wishes of his subscribers, to whom he begs to return his most grateful thanks, for their kind patronage.

In a work of this nature, it is evident that literary composition is out of the question. All that has been attempted, is simply an examination of the chemical composition, together with the mode of manufacturing, that important class of chemical bodies employed by the artist as pigments; and if

it should in any way tend to the advancement of an art so valued and interesting, the author's most sanguine wishes will be accomplished.

The work, as originally intended, would not have exceeded the size of a small pamphlet; but in following out the design, the author has been obliged to extend the work to its present size.

London:

Aberdeen Place, Maida Hill,

Oct. 1837.

INTRODUCTION.

CHEMISTRY is a science so extensive in its operations, that it is almost impossible to conceive any one act of our lives that is not either directly or indirectly dependant upon it. When we contemplate the immense mass of organized life, and the still more stupendous accumulation of inorganic matter, surrounding us on every side; and when again we reflect upon their mutability, we are irresistibly led to the startling conclusion that all is one grand and mighty system of changes. And further, when we understand that Chemistry is effecting these mighty works, that that which is commonly attributed to the action of time, is merely certain chemical operations which have taken place, and that the apparent annihilation of one body, is but in fact the production of another. When we are told that all organic matter is composed of three or four elementary principles differently combined; that the only chemical difference between the mighty Cedar and the humble Lily, or between the bye gone Mammoth and the simple Fly, is in the quantity and arrangements of these few principles. And again when told that the atmosphere, and the poisonous and corrosive acid aqua fortis, contain precisely the same elements differently combined; that two gases by uniting together will produce a solid; that two solids in like manner will become fluid; that

two inert bodies by union form a virulent poison ; that two poisonous bodies by union produce one totally inert ; these and numerous other facts of a similar description may perhaps serve to convey some idea of the importance of Chemistry.

Many persons are deterred from entering upon the study of the science, by the supposed necessity of an extensive laboratory, furnished with apparatus, furnaces, and other cumbersome fixtures, entailing great expence. This is, however, a very foolish error ; it is certainly true, that where extensive operations are to be carried on for commercial purposes, an establishment of this kind is necessary ; but the student, whose desire is merely to become acquainted with the leading principles of the science, and who has seldom or ever occasion to work upon quantities exceeding a drachm in weight, it is obvious can require no such outlay. To those of my readers who may have been thus situated, I cannot, I think, do better than direct their attention to the portable laboratories and cabinets of Mr. R. B. Ede,* they are certainly of a very superior order, being neatly fitted up with a variety of the most useful apparatus and chemicals, varying in price from 16s. to £7. 10s.

The utility of the science in the arts generally has never been denied, but there are some persons who consider that a knowledge of Chemistry would contribute but little benefit to the fine arts, or to its cultivators, the common expression

* These Laboratories can be obtained through any Chemist or Bookseller in the Kingdom. The London Depot is at 79, Bishopsgate Street Within.

being when spoken to upon the subject—"it is quite enough for artists to use the pigments, without harrassing their brains as to how they are made, or what substances enter into their composition."—Such opinions, I am happy to say, are expressed by a very small minority, and are in most cases only so expressed from a deficiency of that knowledge of its importance, which once in possession of, could not fail to point out, not only, its close connexion, but also that the labours of the artist would indeed be circumscribed, were it not for the varied pigments which Chemistry lays open to him.

It is an established fact, the truth of which is incontrovertible, that the science of Chemistry is enabled to exist and flourish in all its varied branches, without the aid of painting; yet the latter would, if deprived of its assistance, instantly cease to exist.

The pigments employed by the artist, are the result of regular and definite *chemical* combinations, of a certain number of simple substances, called by the chemist, elements. Some few of them are found ready formed by the hand of nature, as the Ochres, Black Lead, Vermillion, Orpiment, Mountain Blue, and others; but the far greater number are formed by the chemist in his laboratory.

Chemistry has unfolded a series of beautiful tints, by the varied combinations of these elementary substances, ascending from the lowest ray of the prismatic spectrum, to the highest. All are not, however, of equal importance and utility to the

painter. That unerring mutability of matter, which is ever taking place, acts with varied degrees of intensity on these bodies. This constant change is but, however, the result of other chemical combinations; and must, of course, be effected by the entire change or decomposition of the body acted upon. Thus, many very beautiful pigments are no sooner produced, than an instant change in their composition takes place, by the action of other bodies to which they are opposed, as light, air, &c., &c.

It therefore becomes imperative on the part of the painter, to make his selection of those most fitting, durable, and pure. But how is this to be effected if he be ignorant of their composition, the nature of the elements forming them, and the properties they assume when in combination? Thus, the well known elementary body mercury, and the element iodine, by union, form a new pigment of the most vivid scarlet colour, called intense scarlet. Now, to produce this pigment, these two bodies unite in certain fixed and definite proportions; and the slightest variation in the relative quantities, must necessarily alter the colour. (On exposure to the direct rays of the sun, this pigment is quickly decomposed, and of course loses its colour, from the result of the decomposition effected.)

Artists are I believe divided in opinion as to the propriety of employing those pigments possessing the three simple colours, and compounding from them the intermediate tints, or by the employment of a pigment having the required

tint in itself. If the durability be any consideration, we would most unquestionably prefer the latter; but how far the one system is superior to the other in its application to the purpose intended, cannot by the chemist be determined.

It is not simply in the preparation of the pigments that Chemistry lends its aid to the artist, but in an equally important degree it points out to him how he may best mix them on his pallet, to obtain the required tint, without the danger of their so acting upon each other, as to destroy their individual character, and consequently with it their colour.

In a work exclusively devoted to the chemical properties only, it would be out of place, even did we possess the necessary knowledge of directing the artist in the application of his pigments;* it is certain however, that the less they are intermixed with each other, the greater probability of their permanency is obtained; and further, that vegetable pigments are most certainly less durable than those prepared from the mineral kingdom.

In a very interesting and important paper, written by Sir H. Davy, on the composition of certain pigments, then recently excavated at Pompeii, he proved, by analysis, that those of the mineral kingdom were chemically the same as the pigments now in use by the moderns; and as many of the

* The reader should consult Field's work on Chromatography on this subject, it is replete with very valuable information, both to the artist, the man of science, and the connoisseur.

paintings taken from the ruins, and also those which cannot be removed, bear a freshness and vividness of colour scarcely less so than when first executed, a question naturally forces itself upon the mind, as to how this durability was maintained? The query does not certainly admit of an easy solution, but I cannot help thinking that it mainly depended upon the fitness of the vehicle; and where in the modern paintings, the pigments have faded, it may be attributed, if not entirely, still in a very considerable degree, to the vehicle employed, and I much fear very little positive benefit can be expected until some improvement in the latter is effected.

In the arrangement of the following pages, the author has adopted that course which he usually employs in his lectures upon this subject, viz. by commencing with those general principles constituting the laws which govern the combination of those bodies commonly denominated elements, feeling convinced that unless these are understood, it is in vain to expect any solid information from an examination of the former. In the examination of the elementary bodies, after their general properties, will be found the pigments, of which they form the base.

TABLE OF THE CHEMICALS.

WHITES.

White lead	Carbonate of lead	
London and Nottingham whites }	Ditto	phate of
Ceruse white	Ditto	
Flake white	Ditto	copper
French white	Ditto	blackthorn
Roman white	Ditto	
Zinc white	Oxide of zinc	
Tin white	Ditto of tin	
Pearl white, false	Ditto of bismuth	
Ditto true..	Pulverised pearls	e of iron
Constant white ..	Carbonate and sulphate	
	barytes	
White chalk	Ditto of lime	red

h animal

YELLOWWS.

Naples Yellow ..	A compound of the oxide of lead and antimony	little fish)
Massicot	Protoxide of lead	nut
Yellow Ochre ..	Ditto of iron and earthy matter	indigo,
Oxford ditto	Ditto ditto	
Stone ditto	Ditto ditto	
Roman ditto	Ditto ditto	
Brown ditto	Ditto ditto	
Orpiment or King's yellow }	Sulphuret of arsenic	ackness
Madder yellow ..	From the root	es of wine
Gamboge	Gum resin	
Indian yellow ..	Uriophosphate of lime	

iron

CHEMISTRY,

&c. &c. &c.

IN the present state of chemical knowledge, all bodies in nature are said to be composed of one or more of a certain number of simple substances, which have received the name of Elements. These are fifty-four or fifty-five in number, as—

	Atomic Weight.		Atomic Weight.
Hydrogen	1	Cobalt	26
Carbon	6	Nickel	26
Oxygen	8	Iron	28
Boron	8	Manganese	28
Nitrogen	14	Chromium	28
Sulphur	16	Iridium	30
Phosphorous	16	Titanium	32
Fluorine	18	Tellurium	32
Chlorine	36	Yttrium	34
Selenium	40	Zinc	34
Bromine	75	Arsenic	38
Iodine	124	Zirconium	40
Silicium	8	Potassium	40
Lithium	10	Strontium	44
Aluminum	10	Antimony	44
Magnesium	12	Rhodium	44
Glucium	18	Molybdenum	48
Calcium	20	Cerium	50
Sodium	24	Copper	64

	Atomic Weight.		Atomic Weight.
Cadmium	56	Lead	104
Palladium	56	Silver	110
Tin	58	Columbium	144
Thorium	68	Mercury	200
Barium	70	Gold	200
Bismuth	72	Uranium	208
Tungsten	96	Osmium	100
Platinum	96	Vanadium	67

Every substance, whether animal, vegetable or mineral, must be a compound of two or more of these elements, unless the body under consideration be itself an element; thus water is a compound of the elements oxygen and hydrogen, but the diamond is solely composed of the element carbon in a crystalline state.

The term element, as here employed, does not imply that these bodies are positively simple substances, but merely that the chemist is not at present in possession of any mode by which he can resolve them into other substances or into matter less simple. An example may perhaps explain this subject better: The pigment vermilion is a compound of sulphur and mercury; that these two bodies are the only ingredients, is rendered evident by causing them to combine, and vermilion is the result. A person unacquainted with chemistry would very naturally imagine, that as vermilion may be divided into mercury and sulphur, so either of these might be divided into two or more bodies, but such is not the case; the chemist here stops, nor can he by any method at present known decompose either the mercury or the sulphur, and therefore they are pronounced elements, or simple substances. But no doubt is entertained that as the science progresses, many of the bodies, now supposed simple or elementary, will be found to be compounds.

Of these fifty-five simple or elementary bodies, many of them are found but in minute quantities, others again in

great abundance, and some have never yet been obtained in an elementary state.

Besides these, which are called ponderables, there are others, which have received the name of imponderables, such as light, heat, electricity, and magnetism. The last two are now generally included under the common name of electricity, and many are of opinion that they are the same agent under different modifications.

It is the general opinion, that any mass of matter is composed or made up of minute elementary atoms, which are held together by a force called attraction of cohesion.

The word atom must of course allude to the smallest possible particle, either of an element or of a compound, and is sometimes denominated an integrant particle, or the ultimate atom of a mass, which may either be a simple or compound particle.

Attraction of cohesion, or as it is sometimes called aggregation, is that force by which the particles of a solid or a liquid are held together, so as to form an aggregate or mass, and by the increase or diminution of this force, is the body hard, soft, or friable; by a still further decrease, a liquid; in the gases, it appears to be totally overcome by repulsion. The particles of solid bodies are by some supposed never to be in actual contact, being surrounded by an atmosphere of repulsion, and the superiority of the latter force over the former constituting the three forms of matter, viz.—solid, liquid, or æriform.

Now if we left the subject here, few would be disposed to dispute that a large mass must be made up of masses smaller than itself, but there are other properties with respect to this elementary atom of far greater importance.

Thus, as before stated, all matter is composed of one or more of a certain number of simple or elementary bodies. In the Mosaic account of the formation of the earth, the Almighty Architect in the beginning of time created the heavens and the earth, and after it was created, viz. the

earth, it was without form and void; therefore, we may very naturally conclude, that the first act of the creator was to call into existence the elementary substances, out of which all bodies, whether inanimate or animate, were afterwards to be formed. Now whether we have arrived at the knowledge of these bodies is very doubtful, but that we can resolve all the forms of matter into one or more of a certain few, which few we are unable further to change, is certain, and therefore these bodies we must consider for the present as the original elements, first created.

These elementary bodies then are made up of minute elementary atoms peculiar to each.

It has been a disputed point amongst philosophers for thousands of years, and the subject is far from being definitely settled by the universal acceptance of either of the two hypotheses, viz. whether matter is capable of infinite division, or whether there is a point at which any further division is impossible. The present chemical school nearly all agree with the latter, viz. that the division of matter is finite. At the same time, although this division be limited, yet it is far beyond our power to arrive at it. Thus, as in the following example, although the division of the body be carried to an extent almost incredible, still we are very far from the point of limitation. The celebrated philosopher Boyle, calculated that gold may be extended under the hammer into continuous leaves of such extreme fineness, that fifty square inches of it would only weigh $1\frac{1}{4}$ grain. Gold wire, as it is termed, is merely silver wire surrounded by a thin film of gold; and it has been computed, that if these films were piled one on another to the height of an inch, it would require 14,000,000 of them to effect it. In this distribution of gold it has also been estimated, that one single ounce might be extended to a distance of 1300 miles. Many other examples might be given of the extreme divisibility of matter, in the other two kingdoms, but the above are sufficient to shew the amazing extent to which the division of a

body may be carried. A particle of gold, weighing only the 100,000th part of a grain is visible to the naked eye; now it is not far from the fact, if we say that the ultimate atom or integrant particle of the element gold may be a million times smaller than this—the ultimate atom or integrant particle is therefore invisible.

DIVISIBILITY

Is a property which all bodies, mechanically speaking, possess; thus it is possible to imagine, (although quite impossible to execute) the division of an object, so small as only to be seen with the aid of a microscope, into an indefinite number of smaller particles.

But according to the chemical theory, although this division is capable of being extended to a degree far beyond our limits of comprehension; yet there is a point beyond which it cannot be carried; thus the atom of hydrogen from being the lightest body in nature, is taken as the standard of comparison, or 1: hence if it were possible to arrive at the ultimate atom by mechanical means, say of the diamond or pure carbon, (according to the atomic theory, the ultimate atom of which is 6 times heavier than hydrogen,) therefore, having divided the mass until an atom, weighing 6 times heavier than hydrogen is obtained, it would be impossible to effect any further reduction, it being at that point indivisible, and is in chemical language denominated the ultimate atom; which ultimate atom must be indestructible, impenetrably hard, and of the same form and size as that which it originally possessed when first created. Thus, supposing the ultimate elementary atom to have the form of a cube, it cannot have lost the slightest portion of that shape, even though exposed through a succession of ages to the common abrasion, which we know to be the result of one mass made to rub against another. For if a portion of that shape be changed, then is the ultimate atom no longer of finite division.

When bodies chemically combine, it is said to be effected by their uniting atom to atom, the ultimate atoms of a com-

pound must therefore necessarily consist of two or more simple atoms, these of course can be resolved into the atoms composing the compound, or its constituent particles, as in the case of the vermilion; but the elementary atoms thus separated, cannot be further subdivided.

There are several other general properties possessed in common by all forms of matter, but strictly speaking, they are more under the province of the natural philosopher than the chemist,—as Extension and Divisibility, already noticed—together with

IMPENETRABILITY.

This power is proved by the simple fact, that no two bodies can occupy the same space at the same moment.

Although several chemical combinations seem to militate against this property of matter, still, by a closer examination, we shall find they do not in any way interfere with it.

Thus if a pint of oil of vitriol and of water be mixed, we find they fall short of a quart, but then they have increased in density, by the interstices of the one admitting the particles of the other.

This may be familiarly explained by filling a vessel with bullets; being spherical bodies they cannot touch in all parts, consequently, certain spaces or interstices are left; into these, bullets of a less size may be placed; the interstices left by them will still take small shot; sand may afterwards be placed even between these; after which the vessel will still be enabled to retain some considerable quantity of water, and the interstices left by the water may be filled by a solution being effected between that fluid and common salt.

In this experiment, it is evident no two bodies occupy the same space, although much was added after the vessel was, in common language, full.

POROSITY

Is common to all forms of matter, even to those of the hardest nature, from which it is evident that the particles forming the aggregate cannot touch at all parts. It has even

been conjectured, that the particles are never in any case in actual contact, being surrounded by an atmosphere of repulsion, if it may be so called. (See Arnot's *Physics*, vol. i. page 28.)

COMPRESSIBILITY

Follows, as a natural conclusion, from the preceding observation, for the particles, not being in the nearest possible contact, can be made to approach closer together by pressure, those bodies which recover their original dimensions and form, upon the removal of the pressure are said to be elastic, as the gases, steel, &c.

POLARITY

Is a certain arrangement which the atoms of a mass, whether simple or compound, invariably take, in a regular and determinate manner, when they are free to move; this fact is best exemplified by the crystalline forms of salts, and other bodies.

ATOMIC THEORY.

The law of definite proportions, or the atomic theory, from being founded on the hypothesis of bodies combining atom to atom, is one of great importance, singular beauty, and simplicity.

When bodies combine, it is said to be effected by the union of their elementary atoms; now it is a necessary consequence, if the ultimate atom be incapable of further division, that any such combination as an atom of one body combining with one atom and a half of another, must either be an error in the calculation or in the hypothesis; for, if the ultimate atom be incapable of further division, any thing like half of that which cannot be divided, must be ridiculous; therefore if one body combines with another in more than one proportion, the second and third proportions must be multiples of the first. Thus, if the first compound consists of one atom of each of its constituents, the second and third must be as one to two, or one to three, and this hypothesis is found to be correct, with the exception of a few

compounds; the variation is however supposed to be more in our imperfect knowledge of those compounds, than in any error existing in the hypothesis.

We are indebted to the celebrated Dr. Dalton, for carrying out this beautiful theory, now universally called the Daltonian Theory.

From certain calculations, which it will not be necessary for us to enter into, he has deduced the relative weights of these ultimate atoms, from their combining proportions.

Thus, when oxygen and hydrogen combine to form water, the proportions by weight are as eight to one; that is, in every nine parts of water, there is eight parts of oxygen and one of hydrogen; as bodies combine by joining atom to atom, these weights are supposed to represent the relative weights of the atoms of these bodies, that is, the atom of oxygen is eight times heavier than the atom of hydrogen, and, from the fact of hydrogen being the lightest body in nature, it is taken as the standard of comparison, or 1. Now it is evident, that if the atom of oxygen be represented by 8, that must be its lowest combining proportion, and if it should combine with hydrogen in any other proportion, as the atom cannot be divided, it must be represented by $8+8=16$, or two atoms. Not only is 8 the combining proportion of oxygen with hydrogen, but that number represents its combining proportion with all other bodies. Oxygen, and azote or nitrogen, combine in five different proportions, and we shall find by referring to the table below, that each additional combination of oxygen is exactly a multiple of its combining proportion: the atom of nitrogen compared with hydrogen, is as fourteen to one.

	Nitrogen		Oxygen
Prot-oxide	14	or 1 atom	$8=1$ atom.
Deutoxide	14	ditto	$16=2$ ditto
Hyponitrous acid	14	ditto	$24=3$ ditto
Nitrous acid	14	ditto	$32=4$ ditto
Nitric acid	14	ditto	$40=5$ ditto

If any additional evidence be necessary to establish the truth of the atomic theory, we have it in the fact that in all compound bodies, whether formed by the hand of nature thousands of years back, or in the laboratory of the chemist at the moment we are now writing, they will be found by a correct analysis, to give precisely the same definite proportions; as in water, whether obtained from the lowest depths of the earth, from the atmosphere, from the torrid or the frigid zone, or whether formed now by the chemist in his laboratory, it will be found to consist of eight parts of oxygen and one of hydrogen by weight in every nine parts, or by decomposition is resolved into two volumes of hydrogen and one of oxygen gas.

Not only does this law hold good with the above compound but with every other; and moreover, to obtain the same compound the proportions must be the same, or a new compound is the result. From the examples already given, it is evident, that the constitution of a compound, is regulated by fixed and unalterable laws, and for any body to retain its peculiar and characteristic properties, the elements composing it must be united together in the same definite proportions.

The weight of a compound body is deduced from the relative weights of its constituents; thus the atomic weight of water is 9. viz. hydrogen 1 + oxygen 8 = 9. So in like manner, the atomic weight of oil of vitriol must be forty, it being composed of one atom of sulphur = 16, and three atoms of oxygen = $3 \times 8 = 24 + 16 = 40$.

The further consideration of this law, will enable us to understand the mutual decomposition of two neutral salts, producing two compounds totally different from either previous to decomposition. Thus we have stated forty to be the atomic weight of oil of vitriol or sulphuric acid; now we shall find that thirty-two parts of soda, (consisting of sodium 1 atom = 24, and oxygen 1 atom =

8+24=32,) will exactly saturate these forty parts of acid, and also, that twenty eight parts of lime, (consisting of calcium 1 atom=20, and oxygen 1 atom=8+20=28,) or 78 parts of baryta, consisting of barium 1 atom=70, and oxygen 1 atom=8+70=78, will, in like manner, saturate the same quantity of acid; now, not only do these several proportions of lime, soda, and baryta saturate this quantity of sulphuric acid, but they are also equivalent to the saturating point or the atomic proportions of the other acids. Thus nitric acid is a compound of 1 atom of nitrogen=14 and 5 atoms of oxygen $8 \times 5=40+14=54$. Therefore, supposing the lime to combine with the nitric acid, the atomic weight of the nitrate of lime thus produced must be $(28+54=82)$, and of the nitrate of baryta 132, for $54+78=132$; and if the soda was also combined with the sulphuric acid, we should have seventy-two for its atomic weight $(32+40=72)$. From this it is evident, that if the affinity of sulphuric acid for baryta be stronger than its affinity for soda, two neutral compounds, as nitrate of baryta and sulphate of soda, would mutually decompose each other, producing two other neutral compounds by the acids changing bases, namely, sulphate of baryta and nitrate of soda.

SOLUTION.

The solution of a solid in a liquid, as common salt in water, is one of the most simple examples of chemical combination, and is effected by the atoms composing the mass being forced farther from each other by the attraction of cohesion being destroyed by the affinity of the liquid for the solid: the latter is at any time recoverable unchanged.

To understand how the solution of a solid in a liquid is effected, we must bear in mind the two opposite forces acting upon the mass. First, the cohesive force of the atoms of the solid, by which it is held together, and secondly, the affinity of the liquid for the body acted upon. Where the cohesive force is enabled to resist that affinity, the body is said to be insoluble: thus a lump of marble is not acted

upon by water. When, on the contrary, the affinity is greater than the cohesive force, the body is soluble, the solution gradually proceeding to a certain point, at which point all further action ceases, the two forces being neutralized. The liquid is then said to be saturated, and the point at which this takes place is termed the point of saturation.

Heat, is known to be the antagonist of cohesion; thus, on heating a solid it expands in its whole volume, the particles of the solid repelling each other, until the cohesive force is so far destroyed, that the body assumes the liquid state; thus hot liquids are generally better solvents than cold ones, but when the heat is withdrawn, that portion of the solid which was taken up is deposited as the liquid cools, (with few exceptions).

Solution, however, is not unfrequently the result of chemical combination; in this case, neither the solvent nor the solid can be recovered, unless the compound which they form be decomposed: Thus calcined magnesia is dissolved by oil of vitriol or sulphuric acid, but in this case the two have entered into chemical union, and we have neither the one compound nor the other separate, but in fact a new compound, possessing new and distinct properties peculiar to itself, nor can we again separate the sulphuric acid and magnesia, unless decomposition be resorted to.

The salts formed with an acid, having hydrogen as the acidifying principle, are supposed to undergo decomposition by solution in water; it is, however, still a matter of dispute, whether such be actually the case, and therefore in an elementary treatise of this nature, it is unnecessary to dwell upon it.

The suspension of a solid in a liquid differs from the preceding, in the division of the two being effected by mechanical means, as in the process of filtration.

CRYSTALLIZATION.

In the preceding section we have seen, that solution

unattended by decomposition, is effected by the destruction of the cohesive force of the ultimate atoms of the solid, by which it was enabled to form an aggregate or mass; that when this change has taken place, the atoms of the solid are no longer visible, being kept asunder either by the interposition of the atoms of the liquid, or by the latter having entered into chemical union with the solid, the two forces, as before shewn, being neutralized; now it is a necessary consequence, should the equalization of these forces be in any way destroyed, some change in the relative position of the two must be the result. Thus on the application of heat more of the solid is dissolved, because its cohesive force is weakened; and in like manner, if by evaporation some of the liquid be withdrawn, the solid, held asunder by that portion of water, is, by its cohesive force, enabled to withstand the action of the remaining portion, and falls down to the bottom of the vessel again in the solid state.

Exp.—Put into a wine glass about two thirds of common salt and one third water, stir them well to effect the entire solution of the salt, and put it aside in a warm room for a few days, a large deposit of small cubic crystals will be formed at the bottom.

From this experiment we are enabled to understand, that the action of the cohesive force, is not an indiscriminate rushing together of the atoms, or else no two forms could, even by chance, resemble each other; but here we have, not one but many particles, of a clear and definite geometrical form, the figures being cubes; these are called crystals, and the act crystallization. The process may be repeated a thousand times, and with precisely the same results.

This arrangement of the atoms of a mass when free to move, takes place, with few exceptions, throughout the whole range of bodies termed salts, each salt seeming to possess a form peculiar to itself, reducible however to a few primitive forms; the metals also, by a peculiar process, may be made

to crystallize. Several theories have been promulgated to account for this definite arrangement of ultimate atoms, but little is at present known, beyond the mere fact of their various forms, and that of their possessing such power.

CHEMICAL COMBINATION.

Exp. 1.—Into a wine glass of water place a few clippings of sheet copper, no change takes place; add to the water a little nitric acid, or aquafortis, and the copper is immediately acted upon, rapidly disappearing, and a blue liquid remaining.

From this experiment we learn the fact, that aquafortis has an affinity to combine with copper when oxidized, and by an examination of the change taken place, we shall find the identity of the copper and aquafortis entirely destroyed, a chemical combination of the two bodies being the result; the liquid is now a solution of nitrate of copper, that is, a compound of nitric acid and oxide of copper.

Exp. 2.—Into a small phial, put a mixture of one third water and a third of olive oil, these, if shaken together, will separate unaltered; add to the mixture a small quantity of strong hartshorn or ammonia, and agitate it, when the oil no longer separates, the addition of the third body rendering the oil miscible in water, forming an ammoniacal soap of hartshorn and oil.

Exp. 3.—Into a wine glass containing water, add a small quantity of calcined magnesia, a milky fluid is the result, the magnesia being only mechanically suspended, and would finally settle to the bottom by its superior weight; to this mixture add a small quantity of sulphuric acid, the magnesia disappears, and can no longer be separated by mechanical means.

The rationale of these three experiments, is simply, that the body last added to the several mixtures, possesses a chemical affinity to combine with the bodies previously unacted upon; and, further, it may be taken as a general rule, that when bodies chemically combine, the identity of the

combining bodies are, with few exceptions, totally destroyed.

Thus, in Exp. 3, the result of the combination is the well known compound Epsom salts, formed by the union of two bodies, differing in every respect from each other.

ELECTIVE AFFINITY.

Exp. 4.—Immerse a steel knife in the blue liquid of Exp. 1, the knife will be coated with copper, and if allowed to remain in the solution sufficient time, the whole of the copper will be transferred to the knife, and the liquid will be no longer of a blue colour, but a light green.

Exp. 5.—To Exp. 2, add a few drops of aquafortis, the oil will be again separated.

Exp. 6.—To Exp. 3, add a small quantity of salts of tartar, or carbonate of potass, the magnesia will be again precipitated.

These experiments are intended to explain a power possessed by chemical bodies, called elective affinity. In Exp. 1, we found that aquafortis was disposed to combine with oxide of copper, but the instant the knife was introduced, the copper immediately appeared again, and if the knife had been accurately weighed, it would be found to have lost in weight, being, in fact, partly dissolved by the acid, in preference to the copper revived; thus the affinity of the acid for oxide of iron, is greater than that exerted for oxide of copper.

In Exp. 5, the affinity of the acid for the ammonia, was greater than the latter for the oil, hence the oil was set free, and the acid and ammonia entered into combination.

In Exp. 6, the potash, added to the Epsom salts, consisting of oil of vitriol and magnesia, combines with the acid by its superior affinity, and therefore displaces the magnesia, which falls to the bottom of the glass.

By an attentive examination of these experiments, we learn certain important chemical facts, upon which depends the process of analysis. Thus if we suspect a compound to

contain copper, we know that iron will decompose solutions of copper, and if copper be present it will become visible by being precipitated.

This superior affinity of one body over another, soon led to the discovery of an elective attraction presiding over all bodies; hence, tables were constructed, by which at mere inspection, we may ascertain the attraction of one body towards others. Thus:—

Sulphuric acid

Baryta

Strontia

Potass

Soda

Lime

Ammonia

Magnesia

To understand this table, we will suppose that we have a solution of Epsom salts, or sulphate of magnesia, and we are desirous of obtaining the magnesia from the compound. By reference to the above table, we find that ammonia, by its standing above the former, possesses a stronger affinity for the sulphuric acid, or oil of vitriol, consequently, if the latter be added to the Epsom salts, the magnesia is immediately thrown down.

The change resulting from the addition of ammonia to the Epsom salts, consists in the acid leaving the magnesia which is thrown down, the former combining with the ammonia, forming sulphate of ammonia. If the next above that be added to the last mentioned compound, it is in like manner decomposed; viz. the lime; if to that we add soda, it will decompose the sulphate of lime, and so upwards to the top of the column.

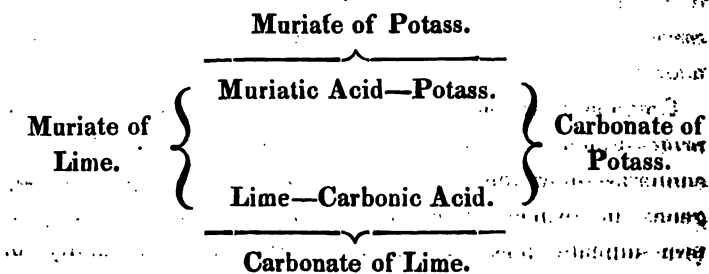
These changes are effected then, by the force of elective attraction, or affinity.

We have yet another form, similar in some respects to the preceding, to examine, viz.

DOUBLE ELECTIVE AFFINITY.

Exp.—Into a tea cup, containing a small quantity of muriatic acid; (hydrochloric acid,) continue to add small pieces of chalk or marble, until they cease to be dissolved; the compound resulting is called when dry chloride of calcium; or in the liquid state, muriate of lime; in a wine glass have ready dissolved some salts of tartar, or carbonate of potass, add the two together, and a bulky white substance will be formed, which if allowed to subside, will settle at the bottom of the cup, a clear liquid floating on the surface.

The example above is intended to explain the nature of the force called double elective affinity, and the change may be represented by the following diagram.



Thus the muriate of lime, to the left of the diagram, consists of muriatic acid and lime, the salts of tartar on the right, of carbonic acid and potass; on mixing the two, mutual decomposition takes place. The muriatic acid quitting the lime, combines with the potass, and the carbonic acid of the potass leaves it also to combine with the lime, these are represented above and below the brackets; the carbonate of lime being insoluble, forms the white bulky substance at the bottom of the cup, the clear liquid being the muriate of potass, the composition of each being represented within the brackets (*See Atomic Theory*).

This subject is of some considerable importance, as upon it depends the formation of nearly the whole of the artificially formed pigments.

CHEMICAL NOMENCLATURE.

The system of naming chemical bodies, if of an elementary nature, from some characteristic feature possessed by them, and if compound, from the constituents composing the body, is a considerable improvement over the old and fanciful names which were formerly employed.

Thus, as elementary bodies, we have *chlorine*, from the green colour possessed by it in its gaseous state; *iodine*, from the violet colour of its vapour; *chromium*, from the variety of colours produced by the combination of that element with other bodies. *Hydrogen*, signifies to generate water. The gas called *oxygen* takes its name from its base being formerly supposed to be the principle of acidity; *azote* receives its name from its incapacity of supporting life; *carbon*, signifying coal; and many others in the same manner.

Compound bodies are named from their constituents; as proto-sulphate of iron; which was formerly called green copperas—now the latter does not convey any intelligence in respect to the nature of the compound, as the term sulphate does; we know that the body is a compound of sulphuric acid and a base; and further we know, that if the proto-sulphate of iron is reduced to its ultimate elements, that we shall obtain sulphur and oxygen, forming the sulphuric acid, which is combined with iron and oxygen, forming the protoxide of iron, green copperas being a sulphate of the protoxide or first oxide of iron.

When oxygen enters into combination with any body, the compound resulting is either an oxide or an acid.

It not unfrequently happens, that oxygen, like other bodies, combines in more than one proportion with other elements. The oxides formed by these several proportions are distinguished by prefixing the words proto, deuto, trit, and per. Thus we have the protoxide for the first combination, deutoxide for the second, tritoxide for the third; and if

the metal be at its acknowledged maximum of oxidation, it is then called the peroxide.

If the compound formed by the union of oxygen and a base be an acid, the quantity of oxygen is denoted by the terminations *ous* and *ic*, as the sulphurous acid, and sulphuric; nitrous and nitric. The names of the compounds of the latter end in *ate*, as sulphate, those of the former in *ite*, as sulphite. Oxygen is not as it was formerly supposed the only element capable of forming acids, for hydrogen possesses the same property. Acids formed by the union of hydrogen and a base are distinguished by the word hydro, going before, as hydro-chloric acid; hydriodic acid signifies an acid composed of hydrogen and iodine; hydro-cyanic, an acid composed of hydrogen and cyanogen.

The vegetable acids are a class of bodies possessing the same characteristic properties as the mineral acids, but in most cases less energetic in their action; their composition in general consists of oxygen, hydrogen, and carbon. Oxalic acid is however an exception, as it consists of carbon and oxygen only; they are named generally from the sources from whence they are obtained. Thus, oxalic acid is so called from having been first obtained from the *oxalis acetosella*, the citric from lemons, the tartaric from tartar, the malic from apples, &c. &c. In order to obtain some of these bodies, they require to be submitted to the action of fire, hence they have the word *pyro*, to burn, prefixed; thus we have the pyroligneous or acid of wood from being obtained by heat.

The following Table has been arranged with a view to explain this system, and if attentively examined, will materially assist the inquirer on this point, which, simple as it is, often presents a formidable barrier to the study of the science, merely from the want of a little attention on the part of the learner.

NOMENCLATURE EXAMPLES.

Common Name.	Composition.	Chemical Name.	Combination Termed.	As	Or
Oil of Vitriol	Sulphur & Oxygen	Sulphuric Acid	Sulphates	Sulphate of Iron	Green Copperas
Acid of Salt	Chlorine & Hydrogen	Hydro-Chloric do.	Hydro-Chlorates, or Muriates	Muriate of Soda	Common Salt
Aqua Fortis	Azote & Oxygen	Nitric do.	Nitrates	Nitrate of Potash	Saltpetre
Fixed Air	Carbon & Oxygen	Carbonic Acid Gas	Carbonates	Carbonate of Lime	Chalk
Phosphoric Acid	Phosphorous & Oxygen	Phosphoric do.	Phosphates	Phosphate of do.	Calcined Bones
Chromic Acid	Chromium & Oxygen	Chromic do.	Chromates	Chromate of Lead	Chrome Yellow*
White Arsenic	Arsenic & Oxygen	Arsenious do.	Arsenites	Arsenite of Copper	Scheele's Green.
Vermillion	Mercury & Sulphur	Bi-sulphuret of Mercury	—	—	—
Hartshorn	Nitrogen & Hydrogen	Ammonia	Amoniurets	—	—
Black Lead	Carbon & Iron	Carburet of Iron	—	—	—

* The names given to the pigments employed by the artist are in many instances both vague and un-descriptive of their character and properties; and I think it not improbable, that they, like the chemical compounds, of which they form a part, may eventually be known to the artist by their chemical names, in preference to those now in use.

IMPONDERABLE BODIES.

HEAT OR CALORIC.

The precise nature of heat still remains in obscurity; two theories at present engage the attention of philosophers. By one theory caloric is said to be a material substance, invisible, imponderable, and of a nature so subtle, as to preclude any direct investigation of its exact nature; the other, on the contrary, imagines caloric not to be material—but that the effects attributed to caloric are owing to the vibrations, tremour, or peculiar motion general to all particles of matter. These theories have been modified by a mixture of both theories; by which hypothesis caloric is considered to be the vibrations of an elastic fluid universally diffused. From these opposite and contending opinions it is evident that the precise nature of caloric is still a matter of doubt. The theory which advocates its materiality is fully adequate to explain in every respect the known and acknowledged phenomena attending it, and, therefore, we shall consider heat or caloric as material.

One of the most obvious properties of the presence of caloric in any body, is an augmentation or expansion in its whole volume. Thus, a rod of metal which will just slip into a corresponding nitch in another piece of metal of the same temperature, upon being heated, expands to an extent sufficient to prevent its insertion into the nitch before mentioned; by which it is evident that the interposition of the particles of caloric must have forced further from each other the particles of iron forming the rod; on cooling, however, the metal contracts, and may be inserted as before. This important fact, simple as it may appear, is still of considerable importance in many mechanical operations; thus the wheelwright on fixing the tire to a wheel, by which the spokes and fellies are bound together, places the iron red-hot upon the wood-work, and of course in an expanded state, it is then

immediately plunged into cold water, which causes the metal to contract, binding firmly together the whole of the wheel. In watches and clocks this expansion by heat, and contraction by cold, becomes of considerable importance. Thus the balance-spring of watches, and pendulums of clocks, are materially influenced in their rate of going, by any increase or reduction in their relative volume. Many inventions have been devised to compensate for this variation in the going of time-keepers, hence they are called compensation balances, or pendulums; the principle of which consists in the employment of metals having unequal rates of expansion at the same temperature, by which the expansion of the one is counteracted by that of the other; the principal forms of these are the gridiron and mercurial pendulums. The balance-wheels of chronometers consist of two arcs of metal, one being generally of brass, and the other of steel—attached to a bar in opposite directions—by which arrangement they counteract the unequal expansibility of each other.

“Solids and liquids expand by heat and contract by cold, but in unequal volumes at the same temperature. To this law, however, there is one grand exception, as in water, which, instead of contracting as heat is withdrawn, continues on the contrary to expand from 40° to its freezing point, or 32°. This wise provision of the Creator is of considerable importance, for ice is thus rendered specifically lighter than water, and consequently swims on the surface; if, however, it continued as in other bodies to contract, as heat is withdrawn it would be rendered heavier, and would therefore sink to the bottom; a fresh portion of ice would be immediately formed, and again sinking, the river would quickly be converted into one solid mass throughout. And as water is almost incapable of conducting heat downwards, it is evident that the sun could never liquify the mass. Again, by this incrustation, the water below the ice is seldom subject to a degree of cold exceeding 40°.

The action of the thermometer depends upon this expan-

sion of liquids by heat. Mercury is the most convenient fluid for denoting high temperatures, its boiling point being considerably above that of all other fluids, and spirit of wine is the most eligible for pointing out low temperatures, because it has never been frozen.

THE THERMOMETER.

The construction of a thermometer is extremely simple. A cylindrical tube of glass is blown at one end into a bulb, which on being heated the atmospheric air is expelled, the open end of the tube is then plunged into a vessel containing mercury; on cooling, a partial vacuum is formed, and the mercury is by the pressure of the external atmosphere forced into the tube to supply the place of the air thus expelled by the heat, which if not in a sufficient quantity, the process must be again repeated; the mercury in the bulb is then made to boil rapidly, by which means any remaining portion of air is expelled by the double action of its rarefaction, and by the expansion of the mercury, which is made to fill the tube; when this is effected, the tube is hermetically sealed; it has then to be graduated, to effect which the bulb is placed in melting ice until the fluid becomes stationary, at which point the glass is scratched, indicating the freezing point of water, which, in the thermometers of this country is marked 32° . It is then placed in boiling distilled water, and when the mercury settles, the glass is again scratched, indicating the boiling point, or 212° . This point, however, is not obtained with the simplicity here given, for the reason that water boils at 212° only when the barometer stands at 30 inches; that is, when the pressure of the atmosphere is exactly 15 lbs. on the square inch.

In this country we may wait for days and months before this point can be obtained, therefore the boiling point is a matter of great nicety. Tables have been, however, constructed by which this variation is rectified. When these points are obtained, the space between the two is divided into 180°; and if the instrument be constructed for the purpose, it

may, in like manner, be extended above or below the points.

GASES AND VAPOURS

Expand equally at the same temperature. This was for many years a subject of dispute, one party contending that the rate of expansion was unequal; the other, for their equality: the latter theory, from the experiments of Gay Lussac and Dalton, is now of course adopted.

COMMUNICATION OF CALORIC.

Caloric is communicated to surrounding objects in two ways—viz. by conduction and radiation.

All bodies may be divided into two classes with respect to caloric, viz. good conductors and imperfect conductors.

The most perfect of the first class are the metals. Thus, if a short metal wire be held for a few moments in the flame of a candle, the heat is quickly felt at the extremity, the caloric being conducted from one particle of the metal to another. Metals, however, differ in their power of conducting heat. Thus copper is a better conductor than iron, &c.

IMPERFECT CONDUCTORS.

Of this class we have silk, wool, fur, down, wood, ivory, glass, &c. &c. These bodies conduct heat, but very imperfectly: thus, a piece of wood, as a common match, may be held in the fingers until the ignited part is almost in contact with them; without the end held by the fingers feeling in any degree warmer.

This variation in the conducting property of bodies is applied to many useful purposes; thus woollen cloths and fur are very imperfect conductors, and consequently are made use of in winter as articles of clothing, thereby preventing the animal heat of the body passing off to the surrounding atmosphere. Metal tea-pots are always provided with a wooden or ivory handle, the latter being but imperfect conductors; defend the hand from the heated metal, which is of the same temperature as the liquid contained therein. On applying the hand to a piece of metal and a piece of wood,

the former always feels colder than the latter; yet, if the temperature of the two be tried by a thermometer, they will be found to be precisely the same. The reason of the metal feeling colder is simply from its superior conducting power, by which the heat of the hand is conveyed away more rapidly than it is generated to supply the loss.

Liquids and gases are generally but imperfect conductors of caloric, if it be applied in such a manner as to prevent the gradual expansion which takes place as it is communicated: thus, if ether be poured on the surface of water, (with which it will not mix,) and the ether ignited, the temperature of the water being previously taken, it will be found when the ether is consumed, not to have received any increase of temperature; but if the same quantity of caloric had been applied at the bottom of the vessel, the water would have been speedily raised to the boiling point. When a fire is applied to the bottom of a vessel containing water, that part immediately in contact with the flame becomes heated, and communicates the heat thus received to the water in connexion with it; this being heated expands, and therefore becomes specifically lighter than the superincumbent stratum, and rises to the surface; a colder or denser portion descending. These ascending and descending currents continue to go on until the expansive force of the liquid is enabled to overcome the pressure of the atmosphere, when it flies off in the state of vapour, being then said to boil. The temperature at which this is effected is called the boiling point of the liquid, which varies in almost every fluid; thus water at the ordinary pressure of the atmosphere, boils at 212° , mercury at 600° , and other fluids at different temperatures.

Heat, however, may be said to have little to do with the boiling of liquids, except when they are under atmospheric pressure; for if the pressure or the superincumbent weight of the atmosphere be removed, all the water on the surface of the earth would quickly rise in the state of vapour. This may

be easily shown by placing water under the receiver of an air pump; upon the air being withdrawn the water boils at 70° at 14° below zero, in like manner, would boil at 44° below zero, and so on. When heat is applied on the surface of the water, and current is formed; for the trifling expansion produced in the upper stratum is sufficient to render it specifically lighter than the under, and consequently to keep it in its situation.

III. RADIATION AND REFLECTION.

When a heated body, as a red-hot iron ball, is suspended in the atmosphere, heat is given out from it in all directions, diverging from the body in lines, called Rays; hence the phenomenon is called radiation, the cause of which is supposed to be, or rather is attributed to, the repulsive property of the atoms of caloric, by which they ever are striving to obtain an equilibrium of temperature.

The properties assumed by radiant caloric, are in many instances dependant on the same laws that govern light, as the following examples will shew.

Polished metals, reflect back the light which falls upon their surfaces. So with radiant caloric, a ray of heat falling on a polished plate of metal, although one of the best conductors, yet does not enter it, but is immediately reflected, (and as with light,) at the same angle. Thus the angle of incidence is always equal to the angle of reflection. Polished metallic surfaces are good reflectors, but bad radiators.

The colour of bodies acts in some manner, at present unknown, with respect to the radiation of caloric. Thus, if a tin cube be filled with boiling water, being previously coated on the outside in the following manner:—one side with black paper, another with white paper, another with a sheet of glass, and the last left polished, they will be found to radiate in the following manner, reckoning the first to be equal to 100, the second will only be 98, the third 90, and the polished surface only 12.

Dr. Franklin is supposed to be the first to have noticed this

singular phenomenon, by simply placing pieces of coloured cloth on snow at the time the sun was shining, by which he found that the snow under the darkest colours quickly melted down, while under the lightest it was scarcely at all affected. Of this fact all persons who have been exposed to the direct rays of the sun during summer in a black dress, must be aware, from feeling in the latter an insufferable degree of heat, which is quickly removed by changing the colour of the dress. Thus in warm climates articles of a light colour, as nankeen, &c. form the principal clothing.

Reflected caloric passes through air without increasing the temperature of it. It appears that the atmosphere is heated by the rays of the sun being absorbed by the earth, whence the heat is radiated to the atmosphere, and this accounts for aeronauts experiencing an intense degree of cold even in summer, although they are actually nearer the source of heat than those on the earth's surface.

This will also explain to us the use of meat screens; the rays of heat, passing from the fire and falling on the polished metal, do not enter it, but are reflected back again upon the meat and fire; hence the positive necessity, if they are to be of any service as reflectors, of keeping them always well polished.

Those bodies which are the best reflectors are generally the worst radiators, and vice versa. Therefore, if our object be to retain the heat in any vessel, the necessity is obvious of having its surface smooth and polished. Thus, if tea be made in a bright metal tea-pot, (free from embossed work or other ornament, which increases its radiating power,) and in one of black earthenware, the temperature being the same in both cases, on standing for a short time the latter will be found to have lost several degrees of heat more than the former. Again, if our object be the conveyance of warm water from the place where it is heated to some distant chamber, as in the different apartments of a bathing establishment, it is necessary that as little of the heat should be lost by radia-

time as possible, the pipes conveying it are therefore always kept bright; so, also, in the cylinders of steam-engines, where the same object is required. On the contrary, where the object is to heat the apartment and surrounding atmosphere by the aid of warm water, &c. then the pipes should be coated black, to increase the radiation of the metallic tubing.

There are many other interesting phenomena connected with this subject, which would occupy more space than could be given in an elementary work of this nature; we shall therefore briefly allude to one of them only, viz.—

LATENT CALORIC.

Latent caloric differs from the preceding state of caloric in not affecting the thermometer, being in combination with some other body; hence it is sometimes called combined or insensible caloric, to distinguish it from the former, called sensible or free.

We are indebted to Dr. Black for the elucidation of many of the phenomena connected with this part of the subject, from which it is generally called Dr. Black's Theory of Latent Heat. One example may, perhaps, better explain what is meant by the term latent heat, or caloric.

Thus quicksilver freezes or becomes solid at a temperature of nearly 40° below zero: that is, 72° below the freezing point of water; now it is evident, that if water and mercury be both cooled down to the freezing point of the former, without effecting their solidification, still the latter possesses locked up or combined with it, so much heat or caloric which it must give out before it can be rendered solid, as would, if added to the former, immediately cause the same to be indicated by the thermometer, being then free or sensible caloric; hence it is called hidden or latent heat.

This latent heat is given out during several processes in the arts, and thus rendered sensible; as when caustic lime is slaked. If water be poured upon unslaked lime, it quickly disappears, the lime being still, to all appearances, as free

from moisture as before the addition of the water, but with the evolution of considerable heat, which the water gives out in assuming the solid state.

Before we can attempt to explain or account for this liberation of caloric, we must understand, that water when converted into ice, requires for its liquefaction a quantity of heat, which would raise the same quantity of water through 140° of the scale of the thermometer; but when thus combined with the ice, (converting it at the same time into water,) becomes absorbed or latent, and consequently does not affect the thermometer. When the water is poured upon the lime, it is by its union with the latter converted into the solid state, and therefore parts with this combined or latent heat, which was necessary to its constitution as a fluid body; the heat being thus liberated becomes sensible or free.

From these observations it is evident that all bodies do not contain the same quantity of heat, although such increase or diminution is not indicated by the thermometer. Hence the terms specific heat, or capacity for heat, which are frequently employed to express the comparative quantity of heat peculiar to each body.

Increase of density is supposed to diminish the capacity of a body for caloric. Thus, when atmospheric air is compressed in a syringe, its particles are made to approximate, and heat is given out in sufficient quantity to ignite combustible bodies. A piece of iron in like manner, when briskly hammered, soon receives an increase of temperature, in consequence of its being made to occupy less space, and its capacity for heat being diminished.

On mixing equal bulks of sulphuric acid, (oil of vitriol), and water together, they do not when mixed occupy a space equal to double their respective bulks; therefore, an increase of density takes place, and heat, as before, is given out.

Increase of bulk, on the contrary, increases the capacity of a body for caloric; thus, in passing from the solid to the

liquid state, bodies absorb caloric from the surrounding objects, thus offering an explanation of the cause of the phenomena of freezing mixtures.

Gases and vapours, when relieved from pressure, expand, and, consequently, suffer a decrease of temperature, affording an explanation of the singular phenomena of the non-scalding properties of high pressure steam when issuing from small orifices. Thus steam is always of the same temperature as the water from which it is generated, yet it obviously contains considerably more caloric, but in a latent state. Mr. Perkins's steam-gun, at the Adelaide Gallery, is worked with steam, at a pressure of 600 lb. to the square inch, the temperature of the steam, whilst in the boiler, is 491° F., from which we should naturally infer, that it would be proportionably hotter than steam generated at the ordinary pressure of the atmosphere, viz, 15 lb. to the square inch; but such steam as it issues from the mouth of the barrel, and expands in the atmosphere, causes the thermometer to fall below 90° ; as witnessed by the Author and Dr. Wilkinson, in a rough experiment made at the Gallery.

VAPORIZATION AND SPONTANEOUS EVAPORATION.

When water is brought to a certain temperature, it gives rise to the phenomenon of ebullition, and is accompanied by the escape of water in the state of steam or vapour; hence the above term. This ebullition is caused by the generation of the steam at the bottom of the vessel. Vapours obey the same laws as the gases, in respect to their expansibility, but with this marked difference, they are not permanent, being immediately reduced to the liquid state by condensation.

All bodies, in passing from the liquid to the aëriform state, absorb a considerable portion of caloric from the surrounding objects; hence the intense degree of cold produced when ether and other volatile fluids evaporate; when this is effected without the application of artificial heat it is called spontaneous evaporation. This spontaneous evaporation is greatly assisted, by removing the pressure of the atmosphere; water,

under the receiver of an air-pump, evaporates at so low a temperature, that the vapour thus generated, from its increased capacity for caloric, robs the remaining water of so much of its caloric as to convert it into ice, even should the sun be shining on the apparatus during the experiment.

LIGHT.

The sources of light are many; among the principal we have the sun's rays, electricity, chemical action, phosphorescence, &c. &c.

The true nature of light is still unknown. Two theories, however, are at present received, differing but slightly from those mentioned in the preceding section, relating to heat. By the one light is regarded as a distinct and peculiar fluid, emitted in right lines, called rays, from all luminous objects.

By the other theory light is considered to be the result of certain vibrations or undulations, of an extremely attenuated and elastic ether, universally diffused.

Sir I. Newton first pointed out, that by the aid of a piece of triangular glass or prism, a ray of white light becomes divided into seven coloured rays, called the prismatic spectrum, consisting of red, orange, yellow, green, blue, indigo, and violet; and by him denominated primitive colours; subsequently, by another analysis, the red, yellow, and blue rays only are considered primitive, the others being formed, or made up from these three: hence they are called compound.

A ray of light in its passage through colourless transparent bodies is but little affected, except the atoms of the body through which it passes are so arranged as to divide it into two rays, or as they are sometimes called pencils of light. This takes place in some crystalline bodies, as in the rhomboidal carbonate of lime, or calcareous spar. The phenomenon is called double refraction.

Black objects absorb all the light that falls upon their surfaces, while white objects on the contrary reflect it back again; others, affording a definite colour, are said to absorb all the rays, except the one forming the peculiar colour which is given out; thus the colour of an object is not a part

or property of that body, but merely dependant upon the arrangement of its parts or texture, or rather we should say upon some unknown cause, by which it is enabled to appropriate certain rays to itself, whilst it gives out others.

The sun's rays have been found to possess other properties besides their illuminating power, which are called the luminous, or colorific rays; these are certain invisible rays, called calorific and chemical. The former received their name from their conveying heat, the latter from their chemical action upon many compounds.

The calorific rays are situated at the extreme verge of the spectrum, or red ray, and appear to decrease in ascending to the violet; they were discovered by Sir W. Herschel: their position and intensity is however greatly modified by the nature of the prism employed.

The chemical rays are situated beyond the violet ray of the spectrum, and were first discovered by Dr. Wollaston. When a mixture of the gases, hydrogen and chlorine, are exposed to the direct rays of the sun they explode, and at the same time their bases unite together, forming hydro-chloric acid gas, (which see); these rays are sometimes called deoxidizing rays, from the facility with which several of the metallic oxides are decomposed when exposed to their action; and it would appear by some recent experiments, that great similarity exists between the effects of these invisible rays, viz. the calorific and chemical rays, and the opposite poles of the galvanic battery, those on the violet side of the spectrum answering to the negative pole, and those on the red to the positive of the battery. It is by the action of these chemical rays, aided by a moist atmosphere, that many vegetable pigments are so quickly deprived of colour. From the preceding observations it is evident, that paintings should never be exposed in any situation where they may receive the direct rays of the sun.

The influence of light on the vegetable kingdom is of considerable importance; thus plants made to grow in a dark

place are devoid of colour; if on the other hand a small opening only be made to admit a few rays, then the plant, if not placed in the immediate direction of the ray, will turn itself, or even grow downwards, that its leaves may be exposed to the action of the light. Another important action of light on vegetables is, its enabling them, during its continuance, to give out oxygen gas, (for the properties of which see Oxygen.) The leaves of trees are said to be the lungs of the plant by which this action is effected; the precise mode is, however, not understood.

Carbon, or charcoal, is the principal element in the vegetable kingdom. Carbonic acid gas, (a compound of carbon and oxygen,) is always more or less present in the atmosphere; on this gas plants are said, during the day, to feed, appropriating to themselves the carbon, and emitting the oxygen.

That light is the cause of this is rendered evident by a reverse action taking place during its absence, as at night, when plants on the contrary give out carbonic acid gas.

Light travels with the amazing velocity of 192,000 miles in a second of time. Thus a ray of light during one beat of the pendulum of a clock, would go from London to Edinburgh 200 times. When a ray of light passes from a rarer to a denser medium at an oblique angle, it is bent out of its due course, and is said to be refracted.

In this short examination of light, we have confined ourselves to its relation to Chemistry, or rather its chemical effects, its other properties being in a measure foreign to our present subject. We may here incidentally observe, that as the colour of an object is not inherent in it, neither does it form a part of that object, depending only for its presence upon some peculiar arrangement of the particles of the body, that the slightest alteration in such arrangement must be accompanied by a change of colour; hence, when it is easily displaced by the facility with which the body is decomposed, the colour of such body or pigment must be of a fugitive order.

HAVING, in the preceding chapters, explained the mode in which bodies chemically combine, we are now prepared to examine the elementary bodies, detailed in the first chapter. It would be useless to enter into an examination of the whole, as many of them are totally unconnected with the subject immediately before us.

In following out our examination, we intend to consider under each element the pigments of which it forms the base.

OXYGEN.

This elementary body was discovered by Dr. Priestley in the year 1774; it was formerly called vital, empyreal, and dephlogisticated air. It belongs to the class of bodies termed permanent gases. It is not absorbed by water, unless the latter be deprived of its atmospheric air by boiling; nor is it of an acid or pungent nature. It is perhaps the most abundant of the gaseous elements, forming one-fifth of the whole atmosphere; entering largely into the composition of water, and of almost all the animal and vegetable bodies, together with the far greatest portion of the mineral products of the earth. Its atomic weight is 8; specific gravity, 1.111. (The specific gravity of the gases are estimated by their differing in weight from atmospheric air, which is taken as the standard, or 1.000.)

The oxygen of the atmosphere is the sole supporter of ordinary combustion, and of animal and vegetable life.

Exp.—To obtain oxygen gas, it is only necessary to heat red-hot, in a gun barrel, (the touch-hole of which has been previously closed,) either the pigment red lead, or an abundant mineral called the black; or peroxide of manganese; an empty bladder may then be attached to the open end of the barrel, with a piece of metal tubing, made air tight by means of clay or putty. The gas will be liberated, and passing into the bladder, may be removed for the purpose of experiment.

Exp.—Fill a glass bottle, holding about a pint, with water and tightly cork it; invert the neck in a basin of water, and while in that state remove the cork—the water will remain in the bottle: bring the mouth of the tube attached to the bladder under the neck of the bottle, slightly pressing it at the same time, the gas will enter the bottle and displace the water; the cork may be then reinserted, and the bottle removed, filled with oxygen gas. Have ready prepared a small stick of charcoal attached to a piece of wire; if this be ignited and plunged into the bottle of gas, it will be found to burn with very great splendour.

By this experiment we learn, that oxygen gas is a powerful supporter of combustion. The process of combustion was formerly supposed to depend upon the union of this gas with the combustible body, and that the process could not be effected unless this gas be present; such, however, is not positively the fact, as several other gases act in a similar manner: but in all cases of ordinary combustion, as in that of coal gas, lamps, candles, coal or wood fires, the presence of this gas is absolutely necessary, the atmospheric air in such cases being decomposed at the expense of the oxygen present.

Previous to the discovery of oxygen gas, it was supposed that all combustible bodies contained a peculiar principle termed phlogiston, which, during the phenomenon of combustion, was liberated, and by its disengagement gave rise to the light and heat.

A small animal, if confined in oxygen gas, will live thrice as long as when confined in the same quantity of atmospheric air.

Any combination of this body is either an oxide, as the red lead, or deutoxide of lead, or an acid, as oil of vitriol, or sulphuric acid.—*See Sulphur.*

Several other bodies by the application of heat afford this gas, as the salt, chlorate of potass, the nitrate of potass, or saltpetre.

When a body combines with this gas, it is said to be oxidised or oxidated; this combination may produce either an acid or an alkali. Should the compound formed present neither of these properties, it is then termed a simple oxide. Deoxidation is intended to signify the depriving a body of its oxygen, as in the reduction of several of the metallic oxides. Thus, if red lead, which is a compound of lead and oxygen, be mixed with charcoal, and heated red hot in the bowl of a tobacco pipe, the lead will be found reduced or deoxidated at the bottom.

HYDROGEN

Is the lightest element in nature, being sixteen times lighter than oxygen, and nearly $14\frac{1}{2}$ lighter than atmospheric air. Its atomic weight is 1; specific gravity, 0.0694. This gas was first correctly examined by Mr. Cavendish, in the year 1766. It forms one part in every nine of water, by weight, the other eight parts being oxygen. Like oxygen, it is a permanent gas, and from its specific gravity being so much less than atmospheric air, it is employed for inflating balloons.

Exp.—To obtain hydrogen gas, place in a 4 oz. phial a few iron filings or nails, or small pieces of zinc, mix previously one part of oil of vitriol with five of water, in the phial, fit a piece of tobacco pipe inserted in a cork, pour the acid and water on the metal, and having permitted the gas to escape for a few seconds, then insert the pipe; if a lighted match be now applied to the orifice of the pipe, the gas will continue to burn as long as it is generated.

Exp.—Suspend over the inflamed hydrogen, in the last Experiment, a clean and dry tumbler, it will immediately be coated on the inside with condensed vapour, and if kept cool and permitted to remain, the moisture would eventually accumulate and run down the glass in drops.

The rationale of this experiment is, that when hydrogen burns in the atmosphere, it does so by its affinity for oxygen, with which it combines, forming water, and flying off in the

state of vapour, but being intercepted by the surface of the cold glass, it is immediately condensed, and reconverted into water.

Exp.—Fill a soda water bottle with water, as directed for oxygen gas, and pass into it two measures of this gas and one of oxygen; if the cork be quickly withdrawn, and a taper applied, the mixed gases explode with a loud report.

In this experiment, as in the preceding, water is generated, the two gases being condensed into water. The report is caused by the rushing in of the atmospheric air to fill the vacuum caused by the condensation.

Water was for many years considered an elementary body. Until the discovery of oxygen gas, the compound nature of water was hardly questioned, unless the surmise of Sir I. Newton, with respect to its containing an inflammable principle, be considered such. The discovery of the above element soon paved the way for the true examination of the nature and properties of this body. Mr. Cavendish having proved by the preceding experiments that when hydrogen burns in the atmosphere, water is invariably formed, led at once to the exact knowledge of its composition. It is now by very accurate experiments determined, that in every 9 parts by weight of pure water, there is 8 of oxygen, and 1 of hydrogen. Water, however, is never absolutely pure in nature; liquified snow is, perhaps, its purest state.

If the two poles of a galvanic battery, terminating in platina wires, be introduced into two phials filled with water, slightly acidulated with sulphuric acid, to render it a better conductor of the electric fluid, and inverted in a basin of that liquid, rapid decomposition takes place, oxygen being given off at the positive pole, and hydrogen at the negative, in the proportion of 2 volumes of the latter to 1 of the former; and as the specific gravity of hydrogen is just 16 times less than that of oxygen, and the two bodies combine atom to atom, it is evident that hydrogen being twice the volume of oxygen, the atomic weight of oxygen must be 8.

Hydrogen with chlorine forms an acid ; with sulphur a gas called sulphuretted hydrogen ; with arsenic a gas also, named arsenuretted hydrogen ; with carbon an important class of gaseous compounds, distinguished by the terms carburetted hydrogen, bicarburetted hydrogen, naptha, &c. &c.

CHLORINE

Was discovered to be an elementary body by Sir H. Davy, in the year 1810, being considered until that time a compound body ; it received its name from the green colour of the gas. Unlike the two preceding, it may by pressure be condensed into a liquid, but immediately expands on the pressure being removed. It has a pungent, suffocating odour, and is highly detrimental to animal life. The atomic weight of chlorine is estimated at 36 ; specific gravity nearly 2.5.

Exp.—Chlorine gas may be obtained by heating in a Florence oil flask, (to which a tube, bent twice at right angles, may be fitted with a cork, and afterwards luted by putty,) 8 parts of common salt, 3 of the black oxide of manganese, 4 of water, and 5 of sulphuric acid, or oil of vitriol, a moderate heat being sufficient. The gas may be collected in bottles as directed for oxygen, substituting warm water for the cold, the gas being rapidly absorbed by the latter.

Exp.—Into the bottle of chlorine gas pour a wine glass full of water, and agitate the mixture for a few minutes ; the gas will be nearly absorbed. If the liquid be now added to a small quantity of the blue tincture of litmus, it will immediately deprive it of colour.

This experiment is intended to illustrate the bleaching properties of this gas, which is now extensively employed for that purpose.

The combinations of this element are numerous ; with the metals and inflammable bodies it forms a class of compounds denominated chlorides.

Exp.—Into a bottle containing chlorine gas, let fall a small piece of phosphorus ; the latter will immediately burst into

flame. The chlorine and the phosphorus have now entered into combination, the result of which is the chloride of phosphorus.

Thus the compounds of chlorine and a base are termed chlorides.

CHLORINE AND OXYGEN

Are by some chemists supposed to combine in four different proportions, viz.

	Chlorine	Oxygen	At.wt.
Protoxide . . .	1 atom 36	+ 1 atom 8	= 44
Peroxide . . .	1 ditto 36	+ 4 ditto 32	= 68
Chloric acid . .	1 ditto 36	+ 5 ditto 40	= 76
Perchloric acid	1 ditto 36	+ 7 ditto 56	= 92

The protoxide is by many chemists considered to be a mixture of chlorine and the peroxide; it was discovered by Sir H. Davy, and by him named Euchlorine; it is a dangerous compound, exploding with great violence if touched by any inflammable body.

THE PEROXIDE

Was also discovered by Sir H. Davy; it is, like the preceding, a gaseous oxide; it is rapidly absorbed by water, and must therefore be collected over mercury. When heated to nearly the boiling point of water, it is decomposed; the decomposition being attended with a violent explosion. These are very dangerous compounds, and should only be examined by skilful manipulators. At present they are of no importance in the arts.

CHLORIC ACID

Is a compound of 5 atoms of oxygen and 1 of chlorine; it has hitherto been obtained only in combination with water, the compounds of which are denominated chlorates, of which the chlorate of potass is the most important.

PERCHLORIC ACID

Is a compound of 7 atoms of oxygen, and 1 of chlorine. It is but of little importance, except as a test for potass.

HYDROCHLORIC ACID

With hydrogen chlorine forms an acid, which, from its constituents, has been named hydro-chloric acid, and its combinations hydro-chlorates, or muriates.

Hydro-chloric, or muriatic acid, (commonly called spirit of salt,) is an acid gas, consisting of equal volumes of chlorine and hydrogen gases, or 1 atom of chlorine, and one of hydrogen: atomic weight 37. It is largely employed for manufacturing purposes, but is never obtained by the direct combination of its constituents. It is usually obtained from the decomposition of common table salt, which consists of this acid, and the alkali soda. The view generally taken of this compound in the present day is, that the two bodies exist in the state of a chloride of the metal sodium; but as this view would require rather an extensive knowledge of chemistry to understand the change effected, we shall consider it in the state first described, viz. muriate of soda.

In order to obtain this acid, common salt is mixed with oil of vitriol and water, in appropriate vessels. The muriatic acid gas is liberated by the superior affinity of the sulphuric acid for the soda, and in that state is made to pass through large bottles containing water, by which means the gas is absorbed, the water, when saturated, forming the common acid, or spirits of salt.

The acid thus obtained has been known for a great length of time, but we are indebted to Sir H. Davy for our present knowledge of its constituents. It is largely employed by the dyers, and in many of the processes in which the metals are concerned. Its combinations are commonly called muriates.

Chlorine, when combined with caustic lime, forms the chloride of lime, or the bleaching powder of the shops. This compound has lately been extensively employed for bleaching, and for the purposes of purifying apartments where contagious diseases are suspected.

Chlorine and carbon combine in various proportions; also sulphur and other inflammable bodies.

AZOTE, OR NITROGEN,

Was declared to be an elementary body in the year 1772, and has never yet been condensed into a liquid. It cannot alone be inhaled for the shortest time, although it forms 4-5ths of the atmosphere. It has neither taste nor smell, and is not absorbed by water under ordinary circumstances; it is 14 times heavier than hydrogen. When pure, it cannot be made to support combustion, burning bodies being immediately extinguished on being plunged into this gas. Its atomic weight is 14; specific gravity, .9722. It enters into combination with oxygen, giving rise to two gaseous oxides, and three acid compounds. With the element hydrogen, it forms ammonia or hartshorn, and with carbon, the compound called by chemists cyanogen.—(*See Carbon.*)

Exp.—Nitrogen gas may be easily obtained by placing a small piece of ignited phosphorus on a cork floating in a soup plate, containing water, by inverting a glass tumbler over it; the latter, though apparently empty, is yet filled with atmospheric air, consisting of 1-5th oxygen, and 4-5ths of this gas; the air included in the tumbler decreases in volume, the water rising to supply its place. The space inside the glass above the water is for a time filled with a white vapour, which however finally becomes absorbed by the water.

The rationale of this experiment is extremely simple. The phosphorus, in burning, combines with the oxygen of the atmospheric air within the glass, by which its volume is decreased, and the nitrogen, when the white vapour has subsided, (*for an account of which see Phosphorus,*) remains nearly pure.

Exp.—While the mouth of the tumbler is under the water, pass a piece of plate glass under it so as to close the mouth, it may then be removed from the plate and inverted, the plate glass acting as a valve, preventing the escape of the gas. Have ready, attached to a wire, a small piece of wax

taper, which on being lit and plunged into the gas, will be immediately extinguished, proving that the gas will not support combustion.

If a small animal be placed in a vessel containing this gas and a valve be immediately placed over the mouth, it dies very quickly. From these experiments we learn, that 4-5ths of the atmosphere consist of a gas fatal to animal life; neither will it support combustion—The remaining 1-5th, viz. oxygen, being apparently the only requisite gas. Nitrogen, although we have no evidence in proof of the fact, no doubt performs a very important office in the economy of nature, at present unknown to us.

Nitrogen and oxygen combine in five different proportions, viz.

	Nitrogen	Oxygen	At.wt.
Protoxide	1 atom 14	+ 1 atom 8	= 22
Deutoxide	1 ditto 14	+ 2 ditto 16	= 30
Hyponitrous acid	1 ditto 14	+ 3 ditto 24	= 38
Nitrous acid . .	1 ditto 14	+ 4 ditto 32	= 46
Nitric acid . . .	1 ditto 14	+ 5 ditto 40	= 54

PROTOXIDE OF NITROGEN.

Exp.—If the compound, called nitrate of ammonia, be subjected to heat in an oil flask, as directed for chlorine gas, the protoxide of this element is obtained, and may be collected in bottles or bladders: from the effect which it has on being inhaled, it has received the name of laughing gas. Nitrate of ammonia is a compound of aquafortis and ammonia, and is easily formed by adding the common volatile salts to the former acid, until it is no longer acted upon. This compound, on being evaporated, yields the salt called nitrate of ammonia, in crystals.

The protoxide consists of 1 atom of nitrogen, and 1 atom oxygen. Atomic weight 22.

THE DEUTOXIDE,

Or, as it is sometimes called, binoxide, is a compound of two atoms of oxygen, and 1 of nitrogen. Atomic weight

30. It may be prepared by dissolving pieces of copper in diluted nitric acid (aqua fortis); by the application of a gentle heat, the gas is liberated, and may be collected as before. It cannot be respired, neither will it support combustion. In permitting it to escape into the atmosphere, it gives rise to dense brown fumes, by its combining with the oxygen present, forming the acid, or brown fumes of nitrous acid.

HYPONITROUS ACID

Is a compound of nitrogen 1 atom = 14, and 3 atoms of oxygen. It is not employed in the arts.

NITROUS ACID,

A compound of 4 atoms of oxygen = 32, and 1 of nitrogen, $14 + 32 = 46$, is therefore its atomic weight. This gas differs from the deutoxide, in its supporting the combustion of a taper and charcoal. It is readily absorbed by water forming an acid liquid.

NITRIC ACID,

Or aqua fortis, is the fifth definite compound of these two gases, and is a compound of 1 atom of nitrogen = 14, and 5 of oxygen = $40 + 54$ the atomic weight. It is obtained for commercial purposes by decomposing the nitrate of potass or saltpetre, by sulphuric acid. The common aqua fortis is always more or less impure; it not unfrequently contains a large quantity of nitrous acid gas, which communicates a brown fuming appearance; it is also frequently contaminated with the sulphuric and muriatic acids.

The salts formed by the union of this acid and a base, are termed nitrates; as saltpetre, or the nitrate of potass, nitrate of silver, or lunar caustic.

Nitro-muriatic acid is a mixture of this acid and the muriatic, forming the aqua regia of the alchemists, or the solvent for gold. The chlorine of the latter acid is evolved on mixing, by which it is enabled to dissolve the gold.

ATMOSPHERIC AIR.

Chemists are at present undecided respecting the exact nature of atmospheric air, viz. whether it is a definite chemical compound, or merely a mechanical mixture of the two gases. Atmospheric air consists of 4-5ths of nitrogen or azote, and 1-5th oxygen gas. It also contains a variable quantity of carbonic acid gas, and watery vapour.

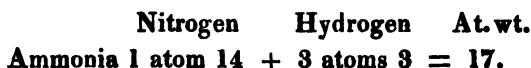
The oxygen of the atmosphere is apparently the only part essentially necessary for the support of animal and vegetable life and combustion. But when we remember the large quantity of nitrogen entering into the chemical composition of most animal substances, it is but natural to imagine the nitrogen of the atmosphere to perform some important part in the animal economy at present unknown to us.

The immense consumption of the vital principle of the atmosphere by the myriads of living creatures, and the various fires and other processes wherein it is absorbed, would naturally induce in the mind the idea, that at times there must exist a deficiency of it; on the contrary, a deficiency has never yet been found of either of the two, nor have they ever been found in any other quantity than that above given. From whence, then, is the supply of oxygen obtained? and how is the equilibrium so universally sustained? To the latter question we are totally at a loss for a reply, and almost equally so with respect to the former. It is supposed principally to be replaced by the action of the leaves of plants.—*See Light.*

AMMONIA ;

Or, as it was formerly called, the volatile alkali, or harts-horn, was first discovered to be a distinct compound by Dr. Priestly: formerly it was obtained only by the decomposition of the horns of the stag: hence its name. It is a compound of nitrogen and hydrogen. These gases when made to combine, in the proportion of one volume of nitrogen and three of hydrogen, produce this pungent compound. It is of a gaseous nature, but may be compressed into a liquid. Imme-

diately, however, on the pressure being removed, it resumes its former state. Its atomic composition may be thus represented :



It possesses properties similar to the alkaline bodies, to be hereafter examined. It is powerfully absorbed by water, that fluid combining with upwards of 600 times its volume. It then forms the liquid ammonia of the shops, or the spirit of hartshorn. Ammonia is now abundantly obtained in the state of an impure carbonate, during the distillation of coal gas.

Exp.—Pour into a tumbler a small quantity of strong spirits of hartshorn, sufficient to moisten the inside, and place a piece of plate glass over the mouth; into another tumbler pour muriatic acid in the same manner, and invert it over the tumbler containing the hartshorn, the piece of plate glass being interposed between the two; then gently withdraw the latter, the tumblers still remaining in the same position; the instant the invisible contents of the two glasses are permitted to act upon each other, copious white fumes are generated, which, if allowed to remain, are finally fixed on the glasses in the form of a white solid, being the muriate of ammonia, or the common sal ammoniac.

Ammonia combines with the acids, forming a class of salts, as the carbonate of ammonia, or the common smelling salts, sulphate of ammonia, &c. &c.

The element nitrogen is one of the component parts of animal matter, from which it may be obtained in great abundance (*see Animal Chemistry.*)

CARBON.

It is a singular fact, that of the two forms of this element one should be the most valuable, viz. the diamond, while the other, comparatively speaking, is the most worthless.

The diamond is pure carbon in a crystalline state. Like

charcoal it combines with oxygen, forming carbonic acid, and may be made to unite with iron, producing steel ; in fact, chemically speaking, the two are identical ; the atomic weight of carbon is 6.

Charcoal may be obtained from either of the three kingdoms, animal, vegetable or mineral. Next to oxygen, it is perhaps the most abundant element.

Lamp black may be considered as the purest form of the charcoal of commerce. It is inodorous, infusible, and incombustible, if heated out of contact with oxygen. The united action of air and moisture has so little effect upon it, that it may be said to be indestructible.

Carbon and oxygen combine in two proportions, forming an oxide and an acid ; the former is called carbonic oxide. It is a compound of 1 atom of each of its constituents, therefore its atomic weight must be $6+8=14$. It is a transparent, colourless gas, and differs from the next compound in being inflammable, burning with a pale blue flame. Like it, however, it will neither support combustion nor animal life. It may be prepared by heating in a glass retort crystalline oxalic acid, and dilute sulphuric acid, the gas as it comes over being collected in the usual manner.

CARBONIC ACID GAS.

If a piece of ignited charcoal be plunged into a jar of oxygen gas, it burns with great splendour. After the combustion has ceased, if the gas be then examined, it will be found to extinguish any burning body plunged into it. The charcoal has combined with the oxygen, forming an acid gas, called carbonic acid, being a compound of one atom of carbon, and two of oxygen. Carbon, 1 atom, 6. + 2 atoms oxygen, 16, + 6 = 22, its atomic weight. It is not necessary to burn charcoal in oxygen gas to obtain it, as it is abundantly given out from the decomposition of chalk or marble, which consists of this acid combined with lime.

Exp.—Into a common beer jug, holding about a pint, put half a wine glass of muriatic acid, diluted with four times

the quantity of water, then let fall a few pieces of marble into the acid and water, effervescence immediately commences, and the carbonic acid gas is freely liberated by the superior affinity of the former acid for the lime: in another jar of the same capacity, place a small piece of ignited wax-taper, then gradually incline the jar containing the gas, as if pouring from it a liquid, into the one having the taper; the carbonic acid gas being specifically heavier than the atmosphere, flows like water, and by its superior weight, displaces the atmosphere in the jar, and the candle, as in the preceding experiment, will be immediately extinguished.

This gas is identical with the choke damp of the mines, the deleterious vapour of lime kilns, and fermented liquors.

All common combustibles give out this gas on burning, their composition generally consisting of the elements carbon, hydrogen, and oxygen: it is also largely generated during the distillation of coal to procure the gas for illumination.

The compounds of this acid are called carbonates.

OXALIC ACID.

Oxalic acid differs from carbonic acid merely in the relative quantity of its constituents; it is like the latter a compound of carbon and oxygen; thus dry oxalic acid is composed of 2 atoms of carbon and 2 of oxygen: atomic weight 28, differing from the preceding in containing two atoms of carbon instead of one. Carbonic acid gas may be taken into the stomach freely, through the medium of the common soda water, champagne, &c.; but by the mere addition of one more proportion of an element, in itself quite inert, we have the deadly poison oxalic acid. This acid was originally obtained from the plant *oxalis acetosella*. It is now however obtained by the decomposition of refuse saccharine matter by nitric acid, or aqua fortis.

Exp.—It may be conveniently obtained by adding together in a tea cup, 4 parts of water, 2 of aqua fortis, and 1 of lump sugar; on the application of a moderate heat a violent effervescence takes place, with the escape of the gaseous deut-

oxide of nitrogen; continue the heat until some time after the sugar is dissolved; the whole being suffered to cool, white crystals of oxalic acid will be found in the liquor.

This acid possesses the strongest affinity for lime of any of the acids, and with it forms an insoluble oxalate of lime; chalk, whiting, or lime, mixed with water, should, therefore, be immediately administered in all cases where this poison has been received into the stomach.

Its combinations are termed oxalates.

HYDRO-CARBONS.

Carbon and hydrogen combine, together forming several distinct compounds, one only of which we shall examine, viz., a compound of the two, called carburetted hydrogen. This compound, with several others of hydrogen and carbon, which are at the same time liberated with it, is employed in the ordinary street illumination, but in this state it is far from being pure: it is, as before remarked, abundantly generated during the distillation of coal.

Coal gas contains, if not thoroughly purified, besides the above gas, bi-carburetted hydrogen, ammonia, sulphuretted hydrogen, carbonic acid, and carbonic oxide. Of these impurities, the sulphuretted hydrogen and ammonia are the most important; the ammonia by its corroding the brass and copper fittings of the gas pipes, forming a compound of the two. The action of the sulphuretted hydrogen will be noticed under the next element.

This compound burns with a bright yellowish flame, varying much in intensity and brilliancy, with the impurities mixed with it. During combustion, the hydrogen of this gas combines with the oxygen of the atmosphere, forming water; and a portion of the carbon with the oxygen, at the same time, forming carbonic acid gas; the other portion of the carbon is deposited, in the form of soot, adhering to every prominent article in the apartment in which it is consumed, unless the combustion be rendered perfect.

Exp.—This gas may be conveniently obtained for the purpose of experiment, by heating in the oil flask, as before directed, a mixture of 2 parts of oil of vitriol, and one of alcohol, or spirits of wine. When pure, it is a compound of 2 atoms of carbon, $12 + 2$ atoms of hydrogen, $2 = 14$.

Exp.—If one volume of this gas be mixed in a tall glass jar with two of chlorine, a valve being placed over the mouth and then inverted, and a light applied to it, the whole of the carbon is decomposed, giving a very good idea of the alteration bodies undergo by chemical union; thus the large quantity of carbon, which is now in the form of a fine black powder, was invisibly combined with the hydrogen. When the light is applied, the chlorine acting upon the carburetted hydrogen, combines with the hydrogen, forming muriatic acid, at the same time liberating the carbon or charcoal.

CYANOGEN

Is a compound of Carbon and nitrogen, which has received the above name; and, as we shall hereafter show the brilliant pigment, Prussian blue, is indebted to this compound for its colour, from which circumstance it received the name cyanogen. It is, when pure, a compound of two volumes of carbon and one of nitrogen; its atomic weight is therefore $12 + 14 = 26$.

With hydrogen this compound forms an acid, which, as it may be obtained from Prussian blue, received the name of prussic acid; in chemical language it is named from its constituents, hydrocyanic acid. It enters into combination with metallic iron, forming ferrocyanic acid; the latter with the peroxide of iron forms Prussian blue.

CHARCOAL.

Wood charcoal is occasionally employed by the artist as a crayon. The woods best adapted for this purpose are those of box and willow; the former affording a dense, compact charcoal, the latter a soft, friable one.

The following is a convenient mode of preparing this sub-

stance: having selected the pieces of wood best fitted for the purpose, shape them to the required form; then place them in a crucible, covering them closely down with fine sand; submit the whole to the action of a strong red heat in a common fire, until they cease to give out fumes; the wood will be converted into charcoal, by the liberation of those substances which were volatilized.

LAMP BLACK.

This substance presents the purest form of charcoal obtained in the large way; it is usually prepared by the combustion of the refuse matter, left by the distillation of resin in preparing the spirits of turpentine. Lamp black, as also ivory black, forms the basis of Indian ink, which is little else than the above bodies, with some glutinous matter to give them consistency. The following method affords one of the purest specimens of carbon, and from its finely divided state, must, I should conceive, prove a very valuable black pigment to the artist,

PRECIPITATED CARBON.

Pour into a retort a mixture of one part of spirits of wine with two of oil of vitriol; have ready a tall glass jar, of at least two feet high, filled with water, and inverted in a vessel of the same liquid; place the retort so that the beak of it may slip under the mouth of the jar; apply a gentle heat to the latter; the mixture will then undergo decomposition, and bi-carburetted hydrogen gas, before described, will be liberated. Allow the gas to pass into the jar until it is one-third full, then remove the retort and contents, and fill the remaining portion of the jar with chlorine gas; close the mouth of the jar with a glass valve, and reinvert it on, removing the latter, at the same time applying a piece of lighted paper to the mouth of the jar; the bi-carburetted hydrogen gas will be decomposed, and a dense precipitation of carbon will take place, which I imagine might be very beneficially employed as a black pigment.

IVORY BLACK.—(See Animal Chemistry.)**SULPHUR**

Is a yellow solid, semi-transparent at the edges, and is both tasteless, and inodorous; when rubbed with flannel it becomes negatively electrified, and is a non-conductor of electricity.

Sulphur, or brimstone, is obtained chiefly from the roasting of metallic ores, with which it is combined, (the ore in which case is said to be mineralized by sulphur); it is also found native in masses, particularly in Sicily, and other volcanic countries.

Pure sulphur has a specific gravity of 1.99; its atomic weight is estimated at 16. The sulphur of commerce is usually sold in two states, viz. roll brimstone, and flowers of brimstone; the former in cylindrical sticks, and the latter in powder.

Sulphur combines with the earths, alkalies, and metals, forming a class of compounds, called sulphurets. It combines also with oxygen in four definite proportions; with chlorine in two proportions, forming the chloride and the bi-chloride of sulphur; it combines with hydrogen also, forming the fetid gas, sulphuretted hydrogen, and with many other bodies.

SULPHUR AND OXYGEN.

	Sulphur.	Oxygen.	At. Wt.
1 Sulphurous acid of . . .	1 atom=16	+2 atoms=16	=32
2 Sulphuric ditto . . .	1 ditto=16	+3 ditto=24	=40
3 Hyposulphurous ditto . .	2 ditto=32	+2 ditto=16	=48
4 Hyposulphuric ditto . .	2 ditto=32	+5 ditto=40	=72

Pure **SULPHUROUS ACID**, at the common temperature and pressure, is a gaseous body, possessing a pungent and suffocating odour; it may be made to assume the liquid state by a pressure equal to two atmospheres, returning to its previous state when the pressure is removed; it may also be obtained in the liquid state by passing it through tubes

enclosed in a freezing mixture; when thus prepared it evaporates at common temperatures so rapidly, that mercury is readily frozen by the intense cold produced.

The peculiar odour attending the burning of sulphur is owing to the presence of this gas, by the sulphur during combustion, combining with the oxygen of the atmosphere. It was formerly employed as a bleaching agent, but is inferior to chlorine; the latter has, therefore, superseded it in most cases. When this acid gas enters into combination with a base, the compound is denominated a sulphite.

SULPHURIC ACID.

The present mode of obtaining sulphuric acid, as practised in this country, is said to be the invention of Dr. Roebuck; it is effected by burning a mixture of eight parts of sulphur and one of nitrate of potass, (saltpetre), in close leaden chambers, containing water to the depth of one or two inches; this absorbs the fumes given out by the sulphur; the process is repeated until the water ceases to take up the gases formed, it is then withdrawn, and concentrated by evaporation, forming the oil of vitriol of the shops; in this state it is a heavy colourless liquid, having a specific gravity from 1.80 to 1.84. It boils at a higher temperature than any other fluid, with the exception of mercury; and requires also an intense degree of cold to freeze it.

When four parts by weight of this acid are mixed with one of water, the temperature of the mixture rises to 300°, or 8° above the ordinary boiling point of water. (See page 28.)

Sulphuric acid combines with most of the salifiable bases; its affinity for them is in many instances superior to the other acids. Its combinations are termed sulphates.

HYPOSULPHUROUS ACID.

The exact atomic proportion of the elements of this compound is still a subject of dispute, some chemists considering it to be a compound of one atom of each of its constituents, others again of two equivalents of sulphur and five of oxygen. It has never yet been obtained in the simple

state, but always in combination with some other body. Its compounds were formerly denominated sulphuretted sulphites. It is not employed in the arts, and may be considered, as well as the following compound, of but little consequence, except to the chemist. Its combinations are termed Hyposulphites.

HYPOSULPHURIC ACID.

This compound of sulphur and oxygen was accidentally discovered by Gay Lussac and Welther, in 1819. Its compounds are denominated Hypsulphates.

SULPHURETTED HYDROGEN Gas.

This compound was discovered by Scheele, in 1777. It is, at common temperature, in the form of gas; but Dr. Faraday, by a pressure equal to 17 atmospheres at 50°, compressed it into a liquid: it, however, immediately returns to its former state on the removal of the pressure. Water may be made to absorb nearly three times its bulk of this gas; and is frequently found in this state in many of the mineral springs, as in those of Kilburn, Harrogate, and Aix-la-Chapelle, &c. The gas is however quickly driven off by boiling, or by long exposure to the atmosphere. When Sulphuretted Hydrogen gas is made to act upon the blue infusion of litmus it slightly reddens it, and it also enters into combination with many of the salifiable bases, forming a class of bodies termed Hydrosulphates; hence, from its similarity of action to the acids, it has been classed among them, and is by some chemists called Hydrosulphuric Acid.

The specific gravity of this compound, compared with atmospheric air, is as 1.17 to 1.00. It is inflammable, and during combustion, deposits the sulphur, previously in combination with it. It is, perhaps, the most poisonous of the gases; for if a small bird be made to breathe common air, containing only $\frac{1}{1500}$ of its volume of this gas, it instantly dies.

Sulphuretted Hydrogen is frequently generated in crowded cities, or where animal matter is undergoing putrefaction, and is therefore sometimes present more or less in the atmos-

phere. It gives rise to that peculiar odour which proceeds from drains and cesspools. It has a very powerful affinity for several of the metallic oxides, more particularly those of lead; the prevailing colours of its compounds are dark browns, blacks, and yellows. As the compounds of lead are extensively employed by the artist, a knowledge of the action of this gas upon them becomes of some importance.

Sulphuretted Hydrogen Gas is readily obtained by heating, in an oil flask, as before directed, a mixture of the common antimony of the shops, (sulphuret of antimony), and muriatic (hydrochloric) acid; the gas is copiously evolved, and may be received either in a bladder or in bottles. It is considered to be a compound of one atom of each of its constituents; hence its atomic weight is seventeen. Thus:

Sulphur Hydrogen At. wt.

1 Atom 16 + 1 atom 1 = 17.

The other compounds of sulphur are not of sufficient importance to need a separate examination.

IODINE

Was discovered in the year 1812, by M. Courtois, of Paris. It is obtained from the residue of the sea waters after the common salt is extracted. The process is both tedious and difficult, and need not be resorted to, as the Iodine, in a tolerably pure state, may now be obtained at a trifling cost. It has a bluish black metallic lustre, is very soft, and in the form of shining plates. It stains the skin of a deep yellow colour, which is however quickly removed by washing the hands in soap and water.. Iodine is extremely volatile, its vapour being of a rich violet colour; from which circumstance it received the above name. Atomic weight 125; specific gravity 4.94; by some 3.08; it melts at 227, and flies off in vapour at 350.

Iodine and Oxygen are supposed to unite in four different proportions, viz. Oxide of Iodine, Iodous Acid, Iodic Acid, and Oxiodic or Periodic Acid; we shall only examine the Iodic Acid, as the former are of little importance.

IODIC ACID

Is considered to be a compound of one atom of iodine, and five of oxygen; viz. $125 + 5 \times 8 = 40 = 165$ its atomic weight; it is obtained pure by rather a complicated process, and possesses a sour taste; is inodorous semi-transparent, and very soluble in water. Its combinations are denominated Iodates: it is not employed in the arts.

Iodine and Chlorine combine, forming an acid, called Chloriodic Acid, of no importance.

IODINE AND HYDROGEN

Combine, forming an acid, considered to be composed of one atom of each of its constituents; hence its atomic weight is $125 + 1 = 126$; when pure it is in the form of an acid gas, which is readily absorbed by water, forming liquid hydroiodic acid; it is colourless and very sour, giving out fumes in the air. Its specific gravity, compared with hydrogen, is as 63 to 1. The acid for commercial purposes is usually obtained by passing a stream of sulphuretted hydrogen through water, holding free iodine in solution; the hydrogen of the gas combines with iodine, forming hydriodic acid, the sulphur being at the same time precipitated.

FLUORINE.

This element, in combination with calcium, exists in the Derbyshire fluor spars, or fluoride of calcium. Dr. Faraday is said to have obtained it in the simple state; its properties are, however, but little known.

PHOSPHORUS,

Carbon, sulphur, and hydrogen, are the four principal inflammable bodies in nature; the metals are also of the same class, but require certain chemical processes to be gone through before they can be made to undergo combustion.

Phosphorus, when newly prepared, and quite pure, has very much the appearance of white wax, but when not pure, has a faint yellow colour; it burns at the common temperature of the atmosphere. Pure phosphorus has a sp. gr. of 1.77, it is insoluble in water, in which liquid it is generally re-

tained, to preserve it from the action of the atmosphere. At a temperature of 550° , if atmospheric air be excluded, it boils and rapidly evaporates. The atomic weight has been estimated at 16. With oxygen it forms an oxide and three compounds of an acid nature, called Hypophosphorous, Phosphorous Acid, and Phosphoric Acid; the latter body combines with the alkalies, earths and metals, forming a class of salts called Phosphates.

	Phosphorus	Oxygen	At.Wt.
Oxide Phosphorus	3 atom=48	+ 1 atom 8=56	
Hypophosphorous acid	2 ditto=32	+ 1 atom 8=40	
Phosphorous acid	1 ditto=16	+ $1\frac{1}{2}$ atom 12=28	
Phosphoric ditto	1 ditto=16	+ $2\frac{1}{2}$ atoms 20=36	

Phosphorus combines also with hydrogen, forming a gas called Phosphuretted hydrogen, possessing the singular property of igniting spontaneously, by intermixing with the oxygen of the atmosphere.

SELENIUM

Was discovered by Berzelius in 1818, in examining a substance found in the sulphuric acid of Sweden. Its discoverer considered it to be a metallic body. It is said to exist in the iron pyrites of the Isle of Anglesey. Selenium possesses a metallic lustre, of a reddish brown colour; in many of its properties resembling sulphur; sp. gr. 4.3. The atomic weight has been estimated at 40. It combines with oxygen in three proportions, forming an oxide, and 2 acids; it is however a very rare substance, and from that circumstance has not yet been applied to any useful purpose.

BORON

Is the base of an acid called Boracic, from Borax, which consists of this acid and soda. It may readily be obtained by dissolving borax in hot water, and adding to the solution half as much of sulphuric acid as of borax: the liquor on cooling deposits the boracic acid in the form of thin scales; this latter substance, when exposed to a strong heat, fuses, and on cooling becomes a hard transparent glass.

Boracic acid combines with the earths, alkalies, and metals, forming a class of salts, termed Borates. When the fused acid is heated in a copper tube with the metallic base of potass (the metal potassium), it is decomposed; the mass being washed and filtered, the boron remains in the form of a brown, insoluble, and insipid powder; which if heated to 600 burns brilliantly. Its atomic weight has been estimated at 20; the acid consists of one atom of boron and 6 of oxygen: $20 + 48 = 68$. With the exception of the combination of the acid and soda, or borax, it is of no importance in the arts.

BROMINE

Was discovered in 1826, by M. Balard, of Montpellier, in the uncrystalline portion of sea-water after the salt is extracted. At common temperatures, it is a deep reddish brown liquid, of a very suffocating odour, and is a violent poison. It seems to bear some resemblance to chlorine and iodine, both being obtained from the same source, so as to lead to the supposition of its being a compound of the two; this opinion however has been found not to be correct. It unites with oxygen, forming a compound, called Bromic Acid. The atomic weight of bromine is stated to be 78, and the acid consists of one atom of boron and five of oxygen $78 + 40 = 118$.* It is not applied to any useful purpose.

* Or referring to the atomic numbers or equivalents of the elementary bodies detailed in the first chapter, they will be found to differ in many instances from those given under the articles to which they belong. The change is owing to the appearance of a standard work on the science, authorising these alterations, during the time these sheets were in the press, and after the printing of the first sheet. The following list will be found to embrace those elements whose numbers have been altered:—

Boron,	from	8 to	20	Antimony	from	44 to	65
Fluorine	—	18 —	16	Rhodium	—	44 —	52
Bromine	—	75 —	78	Cerium	—	50 —	48
Iodine	—	124 —	125	Palladium	—	56 —	54
Lithium	—	10 —	8	Thorium	—	68 —	60
Cobalt	—	26 —	30	Barium	—	70 —	69
Nickel	—	26 —	28	Tungsten	—	96 —	100
Iridium	—	30 —	96	Silver	—	110 —	108
Titanium	—	32 —	24	Columbium	—	144 —	185
Yttrium	—	34 —	32	Uranium	—	208 —	217
Zinc	—	34 —	32	Vanadium	—	67 —	68
Zirconium	—	40 —	22				

METALLIC ELEMENTS.

This important class of simple bodies, constituting nearly four-fifths of the elementary atoms of matter, are distinguished by the following general properties: lustre, opacity, ductility, malleability, and tenacity; they are also good conductors of heat and electricity; their great specific gravity was considered as a distinguishing feature until the discovery of the metals potassium and sodium, &c., which are lighter than water; specific gravity, therefore, can no longer be assigned as a characteristic.

Of the present class of metallic bodies, amounting to 42 distinct metals, a few only were known to the ancients; these were gold, silver, mercury, copper, iron, tin and lead. We are indebted, however, to the alchemists for the principal information which we possess of the above metals; these visionary enthusiasts imagined them to have some mysterious connexion with the heavenly bodies; and hence those names and symbols so often met with in the writings of the alchemists. Thus we find

Gold	was called the Sun
Silver	 the Moon
Quicksilver	 Mercury
Copper	 Venus
Iron	 Mars
Tin	 Jupiter
Lead	 Saturn.

Some writers consider the ancients, to have been acquainted also with arsenic, antimony, zinc and cobalt, but it is doubtful whether they considered them metallic bodies.

The metals are seldom found in the metallic state, but generally combined with some other element, as oxygen, sulphur, arsenic, or carbon, &c., in which state they are said to be mineralized by the element combined.

Gold, platinum, silver and mercury, are more frequently found in the pure state, in which case the term native is applied.

The preceding elements are sometimes denominated, by way of distinction, simple non-metallic substances, as oxygen, hydrogen, chlorine, iodine, &c. &c.; with these many of the metals enter into combination, forming a class of compounds, of which the following are the principal.

Oxygen and Metals form Oxides and Acids

Chlorinedo..... Chlorides

Carbondo..... Carburets

Iodinedo..... Iodurets

Sulphurdo. Sulphurets

Phosphorus ..do..... Phosphurets.

The oxides of the metals, by their union with acids, form a class of compounds called metallic salts; as sulphate of iron, of copper, and zinc.

Metallic acids are a peculiar class of compounds, resulting from the combination of certain metals with oxygen. Among the principal are those of antimony, arsenic, chromium, manganese, &c., in which state they combine with the oxides of the other metals; forming, as before, metallic salts. The metals combine with each other, forming a class of compounds termed alloys, of great importance in the arts, as brass, bell-metal, printer's type, solder, and the standard coin, &c. &c. Should, however, mercury be one of the metals, the compound is then termed an amalgam.

The metals may be divided into three classes, viz.

Class 1. Those which by their union with Oxygen, form Alkalis.

2. Those which by their union with Oxygen, form Earths.

3. Metals, commonly so called.

CLASS 1.

Metals, which by their union with Oxygen, form Alkalis.

1 Potassium,

2 Sodium,

3 Lithium.

CLASS 2.,

Metals, which by their union with Oxygen, form Earths.

4 Barium,	9 Glucinum,
5 Strontium,	10 Yttrium,
6 Calcium,	11 Zirconium,
7 Magnesium,	12 Thorinum.
8 Alumium,	

Silicium,

CLASS 3.

Comm on Metals.

13 Platinum	23 Antimony	33 Tungsten
14 Palladium	24 Tin	34 Molybdenum
15 Rhodium	25 Bismuth	35 Cerium
16 Gold	26 Manganese	36 Columbium
17 Silver	27 Chromium	37 Tellurium
18 Mercury	28 Cobalt	38 Titanium
19 Iron	29 Nickel	39 Uranium
20 Lead	30 Arsenic	40 Osmium
21 Copper	31 Vanadium	41 Iridium
22 Zinc	32 Cadmium	42 Pluranium

CLASS 1.

POTASSIUM.

Potass, or Potash, was formerly called the vegetable alkali, of which the metal potassium is the base.

The latter was discovered in 1807, by Sir H. Davy; he obtained it by submitting the hydrate of potass (the pure protoxide of the metal), to the action of a powerful voltaic battery, by which the oxygen of the oxide was separated, and the metal left pure.

Potassium has the colour and lustre of silver, but so powerful is its affinity for oxygen, that a few moments' exposure to the atmosphere is sufficient to convert it into the protoxide or pure potass; at common temperatures it is readily cut with a knife, and may be moulded by the fingers. Its abso-

lute weight, or specific gravity, compared with water, is as 0.865 to 1.000; it consequently floats on the surface. Its atomic weight is estimated at 40.

Exp.—Place a small piece of potassium in a plate containing water; the water is decomposed, the oxygen being taken up by the metal, at the same time liberating the hydrogen; and so energetic is the action, that a brilliant combustion results. From this experiment it is evident that potassium should be confined in some liquid which does not contain oxygen as one of its component parts; a liquid of that nature is found in pure naphtha, which is a compound of carbon and hydrogen; care however should be taken not to employ the common naphtha of the shops for that purpose, as it contains water.

POTASSIUM AND OXYGEN,

Combine in two different proportions, forming two oxides of the metal; the first of which is of the most importance, being the protoxide or pure potass.

The protoxide of potassium is a compound of one atom of each of its constituents, and may be thus represented:



It is a white solid, of a caustic and burning taste, and when exposed to the atmosphere, quickly becomes converted into the liquid state by absorbing moisture; owing to which property it is said to be deliquescent. It forms, with acids, the various salts, having potassium as a base.

The peroxide of potassium is a compound of one atom of the metal and three atoms of oxygen. Thus:



This compound is formed when potassium is burned in oxygen gas. It is a yellow, or rather orange-coloured solid, sometimes presenting a scaly crystalline texture; when thrown into water it is rapidly decomposed, parting with two atoms of oxygen, by which it is converted into the former oxide.

CARBONATE OF POTASS.

This salt, (which is a compound of 1 atom of the protoxide $48 + 1$ atom of carbonic acid $22 = 70$ at. wt.), is extensively employed in the arts, and passes under a variety of names: thus, in its rough state, it is called wood-ashes; this, when fused, receives the name of pearlash or potash; the latter, when further purified, is called salts of tartar, or carbonate of potass.

Potash, or, as it was formerly called, the vegetable alkali, from being obtained from the ashes of burnt vegetables, is a deliquescent compound, quickly absorbing moisture from the atmosphere; by which it is converted into an oily-looking compound, known in commerce by the name of oil of tartar.

The English market is principally supplied with potass from North America.

BI-CARBONATE OF POTASSA.

This compound was formerly considered as a carbonate, and the former as a sub-carbonate of potass. It is a compound of one atom of the protoxide, and two atoms of carbonic acid, and may be thus represented:

Protoxide of Potassium	Carbonic Acid	At.wt.
1 atom.....	$48 + 2$ atoms....	$44 = 92$

In its crystalline state it is considered to be combined with one atom of water $9 + 92 = 101$ at. wt. of the crystalline bi-carbonate of potass.

SESQUICARBONATE OF POTASS.

This compound of the preceding elements is not generally acknowledged as a distinct compound; it is supposed to be composed of one atom of the protoxide with $1\frac{1}{2}$ atom of carbonic acid.

The two preceding compounds are extensively employed; the former in many processes in the arts; the latter in medicine.

NITRATE OF POTASS.

This salt, as its name implies, is a compound of nitric acid and the protoxide of potassium; its composition may be thus represented:

	Protoxide of Potassium	Nitric Acid	At. wt.
Nitrate of Potass.	1 atom	48 + 1 atom	54 = 102

It is known in commerce under the name of nitre or salt-petre; the principal part of this substance used in England is brought from the East Indies. When imported, it is mixed with a variety of impurities, from which it requires to be purified. It is readily formed artificially by adding diluted nitric acid to a solution of the carbonate of potass, until the escape of carbonic acid ceases; by evaporation the nitrate of potass in crystals of six-sided prisms is obtained.

Nitrate of potass is extensively employed in making gun-powder, of which it forms an important part; it is also employed in medicine in small doses as a diuretic,

Nitrate of potass at a temperature of 600° fuses, without decomposing, in which state it may be cast into moulds; on cooling it forms a white compact mass, presenting a striated appearance, known under the name of *sal prunella*.

SULPHATE OF POTASS,

Is a compound of sulphuric acid and the protoxide of potassium, in the proportions of

	Protoxide of Potassium	Oxygen	At. wt.
Sulphate of Potass.	1 atom	48 + 1 atom	40 = 88.

There is also a bisulphate, containing two atoms of acid, and also a sesquisulphate, consisting of two atoms of the protoxide, and three atoms of acid, neither of which are of any importance.

TARTRATE AND BITARTRATE OF POTASS.

Bitartrate of potass; this compound, when purified, is the cream of tartar of commerce; it is obtained during the process of wine making, being deposited slowly by the juice of the grape, in which state it is more or less coloured, and

is called crude tartar. It is a compound of tartaric acid and the protoxide of potassium, as under :

Protex. Potassium	Tart. Acid	At. wt.
Bitartrate of Potass. 1 atom.....	48 + 2 atoms	132 = 180

The tartrate is artificially formed by adding a solution of the carbonate to the bi-tartrate of potass until the effervescence ceases; by evaporation it forms crystals, which are readily soluble in water, forming a marked difference from the former compound, which is but sparingly soluble in water. It differs from the bitartrate, in having one atom less of acid.

CHLORATE OF POTASS,

Is a compound of chloric acid and protoxide of potassium; and contains one atom of each of its constituents. This salt was formerly called oxymuriate of potass, and is extensively employed in the preparation of the detonating compounds for percussion caps, and those of the lucifer matches, &c., from the facility with which it is decomposed if mixed with any inflammable body when friction or percussion is applied.

IODIDE OF POTASSIUM.

This salt is a compound of iodine and potassium, and is said to consist of one atom of each : viz.

Potassium	Iodine	At. wt.
Iodide of Potassium. 1 atom..	40 + 1 atom	125 = 165

It is frequently called the hydriodate of potass, in which case it is considered to be a compound of hydriodic acid, (which see), and the protoxide of the metal. As an iodide of potassium, it is presumed that when the compound is dissolved in water the latter is decomposed, its oxygen uniting with the metal to form the protoxide, and the hydrogen with the iodine, forming the hydrodic acid. This compound, by double decomposition, furnishes several very beautiful iodine pigments, the colours of which are of a nature too fugitive to be of any use to the artist.

FERRUCYANURET OF POTASS.—(See article Prussian Blue.)

SODIUM.

This metal was discovered by Sir H. Davy, in 1808, to be the metallic base of the alkali soda. He obtained it in a manner similar to that described under the article potassium.

It closely resembles potassium in its appearance, but does not seem to tarnish quite so rapidly when exposed to the atmosphere; when thrown upon water it decomposes it, but without the evolution of light. The atomic weight of sodium is estimated at 24.

SODIUM AND OXYGEN,

Combine in two proportions, forming the protoxide, or caustic soda; composed of one atom of each of its constituents, and the peroxide of one atom of sodium and $1\frac{1}{2}$ of oxygen; and may be thus represented:

	Sodium	Oxygen	At. wt.
Protoxide....	1 atom 24	+ 1 atom 8	= 32
Peroxide	1 atom 24	+ $1\frac{1}{2}$ atom 12	= 36

The protoxide of sodium, and also that of potassium, are readily obtained by adding caustic lime to a solution of their carbonates; the lime combines with the carbonic acid, leaving the protoxide of the metal; this requires to be freed from the lime, evaporated to dryness, and afterwards fused.

CHLORIDE OF SODIUM.

This compound of the metal sodium and the element chlorine, is better known by the old name of muriate of soda (common table salt). The view taken by some chemists relative to this compound, is precisely similar to that given under the article iodide of potassium.

Chloride of sodium is said to be a compound of one atom of each of its constituents. Thus:

	Sodium	Chlorine	At. wt.,
Chloride of Sodium	1 atom 24	+ 1 atom 36	= 60

Chloride of sodium is an abundant natural product; it not only exists in the sea water, but mines of an immense extent have been discovered, consisting almost entirely of

this compound, producing annually many thousand tons. This description of salt passes under the name of rock salt. On referring to the article chlorine, it will be found that muriatic acid is a compound of the elements chlorine and hydrogen, held in solution by water.

Exp.—Into a wine glass containing some of this acid, continue to add small pieces of the common carbonate of soda, until the action between the two ceases. If the compound formed be now tasted, it will be found to differ very materially from either, previous to their being mixed; the liquid has now acquired the well-known taste of common salt, or brine, and if placed in a warm apartment for a few days, cubic crystals of the chloride of sodium, or muriate of soda, will be deposited.

In this experiment we employed muriatic acid and common soda, consisting of carbonic acid and the protoxide of sodium; on mixing them, chemical action takes place; the carbonic acid is expelled by the superior affinity of the former acid for soda, which in its insulated state, is in the form of gas; the bubbles of the latter rising to the surface of the liquid give rise to the phenomenon of effervescence.

The sulphuric, nitric and the vegetable acids combine with the protoxide of soda, forming salts, the general properties of which are very similar to those of the preceding element.

LITHIUM.

The protoxide of this metal is the alkali Lithia. It was discovered in the year 1808 in a mineral called petalite, by M. Arfwedson; it has since been found in other bodies, but the quantity obtained is so trivial, that very little of it is known beyond the mere fact of its principal characters.

The alkali lithia is similar in its modes of action to the two preceding elements, forming with acids neutral salts. The name lithia is derived from its lapideous or stony origin. By submitting the pure oxide to the action of a galvanic battery, oxygen is given off at the positive pole, a brilliant white

metal surrounding the negative pole of the battery, which is the metal lithium.

Its scarcity of course precludes its application to any practical purpose. Its atomic weight has been estimated at 8.

THE ALKALIES

Are a class of bodies distinguished by their acrid, burning and nauseous taste, by their changing the vegetable yellows to browns, and the blues to greens. They combine with the acids, forming a class of salts, which, before the discovery of their several bases, received the name of alkaline salts.

The compound ammonia, (*see Nitrogen*), possesses all these properties, at the same time we know it to be a compound of the elements nitrogen and hydrogen. From this it has been conjectured that the metallic bases of the above alkalies may yet be compounds, or that nitrogen is itself a compound body.

SALTS.

The word salt having several times occurred, and as it will occur again, we may at the present opportunity examine the chemical definition of the term.

In a chemical sense the word salt implies a compound of an acid and a base, as in carbonate of soda, which is a compound of carbonic acid, and the protoxide of sodium, which is considered the base. It is of no consequence of what nature the base may be, as the protosulphate of iron, nitrate of silver, or nitrate of barytes, they are all called salts.

Some salts are called neutral, by which we understand that the properties of acid and base are perfectly neutralized. Thus a compound may be thoroughly saturated and still not a neutral salt, as in the carbonate and bicarbonate of potass. These conditions of acid and base are frequently distinguished by prefixing the words sub and super, as the sub-carbonate of potass, super-tartrate of potass; in the former the alkaline nature predominates, and in the latter the acid.

The term double salt is used to denote a compound of an acid combined with two bases, as the tartrate of potass and

soda (Rochelle salt), tartrate of antimony, and potass, (tartar emetic).

Several new terms have lately been introduced, but their insertion would be out of place in a work of this nature.

CLASS 2.

Metals which by their union with oxygen form earths.

Barium, or the metallic base of Barytes	
Strontium	Strontia
Calcium	Lime
Alumium	Clay
Magnesium	Magnesia
Glucinum.....	Glucina
Yttrium	Yttria
Zirconium	Zirconia
Silicum.....	Flint

BARIUM.

Barytes, or the protoxide of the metal Barium, is one of the heaviest bodies of the class to which it belongs. It is found native in two states, viz. as a sulphate and carbonate of the protoxide. The former is obtained in great abundance from the mines of Cumberland and Westmorland, and also in those of Hungary and Saxony, generally in the form of a dense, compact, yellow mass, which, however, is frequently found crystallized. Its specific gravity is 4.7. This compound, when converted into the carbonate, is extensively employed in adulterating the white lead of commerce, in which state it passes under the name of Dutch lead. It is a compound of one atom of each of its constituents, thus:—

Protoxide of Barium	Sulphuric Acid	At.wt.
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Sulphate Baryta 1 atom 77 + 1 atom 40 = 117.

The native carbonate of barytes was first discovered in Lancashire by Dr. Withering, from which circumstance it is sometimes called witherite. It has been since found in Cumberland, Westmorland, Wales, and several other parts of the kingdom. The carbonate of barytes of commerce is

usually in the form of white globular masses, presenting, when broken, a radiated structure. It is a compound of one atom of each of its constituents, thus :—

Protoxide of Barium Carbonic Acid At.wt.

Carbonate Baryta 1 atom 77 + 1 atom 22 = 99

The former of these compounds is quite insoluble in water, and the latter but very sparingly.

Barium, the metallic base of the pure protoxide was first obtained by Sir H. Davy in 1808, by the aid of galvanism, as described under the metal potassium. It is of a gray colour, presenting when cut a metallic lustre. It rapidly absorbs oxygen, passing again into the protoxide.

Barium has a specific gravity of 2, and its atomic weight is considered to be 69.

PROTOXIDE, OR PURE BARYTA.

Oxygen and Barium combine in two proportions, forming the above and the peroxide, the former of which is obtained by decomposing the pure nitrate of Baryta by heat. It is of a gray colour, having a specific gravity of about 4. It combines with water, with the evolution of heat, forming the hydrate of the protoxide of Baryta.

It is a violent poison; the best antidote for it is dilute sulphuric acid, or the sulphate of magnesia; with either of which an insoluble sulphate of baryta is formed.

THE PEROXIDE

Is obtained by passing oxygen gas through a porcelain tube containing the protoxide, heated to dull redness, by which process the oxygen combines with the protoxide, and a peroxide remains, the use of which is confined to the laboratory for the production of the peroxide of hydrogen. The atomic constitution of the two oxides may be thus represented :—

Barium Oxygen At. wt.

Protoxide 1 atom 69 + 1 atom 8 = 77

Peroxide 1 ditto 69 + 2 ditto 16 = 85

The nitric and muriatic acids combine with the former

of these oxides, forming salts soluble in water, both of which are highly poisonous. They also serve as tests for the presence of sulphuric acid, either free, or combined with any other body, for which it possesses a powerful affinity, falling down in the form of a white insoluble sulphate of baryta.

CONSTANT WHITE.

A very beautiful and permanent white pigment is now made from the artificial sulphate of baryta, which passes under the above name, or Hume's permanent white. It may be thus prepared: reduce the native carbonate to a fine powder, and subject it to a red heat in a crucible, mixed with a little powdered charcoal, for two hours; remove it from the fire, and when cold, add it by small portions to a solution of dilute nitric acid, until the action ceases; filter the liquid, which is now a nitrate of baryta, to which must be added, gradually, a mixture of three parts of sulphuric acid, with eight of water. The latter immediately combines with the baryta, falling down to the bottom of the vessel, leaving the nitric acid floating above it, which may be again and again employed for the same process. The whole must then be thrown upon a filter, and well washed with distilled water, until the latter passes off free from acid, which may be ascertained by its action upon litmus paper; the compound left upon the filter must then be left to dry spontaneously, and forms the constant white.

This compound forms the only positive white pigment of any value to the artist; but, ponderable as this substance is, it is not of sufficient body to work agreeably, forming when the gum is added, a thin milky mass, unlike pigments of the same class produced from the other metals.

CHROMATE OF BARYTA, or LEMON YELLOW.

By adding a solution of the chromate of potass to a solution of the chloride of barium, (muriate of baryta), a very beautiful and delicate precipitate of the chromate of baryta is thrown down, of a fine lemon yellow colour. This pigment

has lately been introduced to the notice of artists by Mr. Field; some mistake appears, however, to have arisen with respect to its composition, many artists considering it to be a compound of the metal platina (which see); it is composed of one atom of each of its constituents, as :

Protoxide Barium	Chromic Acid	At. Wt.
Chromate Baryta 1 atom 77	+ 1 atom 52	= 129

Baryta, strontia, and lime are sometimes termed caustic or alkaline earths, from the resemblance they bear to the alkalies, in their action on the vegetable blues, converting them to greens.

STRONTIUM.

The protoxide of this metal, in combination with carbonic acid, forming the native carbonate, was first discovered in Strontian, in Argyleshire, from whence its name.

The metallic base, or the metal strontium, was obtained by Sir H. Davy soon after the discovery of the preceding metal. It has not been so minutely examined as the metal barium, probably from the close resemblance the two metals bear in their various combinations with the acids. Its atomic weight is estimated at 44.

It combines with oxygen, forming two oxides, which may be thus represented :—

Strontium	Oxygen	At. wt.
Protoxide 1 atom 44	+ 1 atom 8	= 52
Protoxide 1 atom 44	+ 2 ditto 16	= 60

They are obtained by a process similar to that described under the preceding metal, and to the compounds of which they bear a close resemblance.

The protoxide combines with the acids, forming a class of salts, nearly the whole of which, with the exception of the nitrate and muriate, are insoluble in water.

There is, however, one marked difference between these two bodies in the colour they communicate to flame, or when they are made to undergo combustion, baryta giving out a yellowish green flame, and strontia a brilliant crimson one,

for which purpose it is extensively used in scenick effect at the theatres.

CALCIUM.

The protoxide of this metal, or, as it is frequently called, caustic lime, is one of the most abundant of the class. It is found principally combined with the carbonic acid, forming not only the vast and inexhaustible quarries of marble, but also whole ranges of mountains in the state of chalk. These two bodies, as well as several other compounds of lime and carbonic acid, although so different in appearance, are yet chemically the same, consisting of the protoxide of the metal calcium, and carbonic acid, or carbonate of lime.

Lime is also found in combination with the sulphuric acid called gypsum. This latter compound, when heated red-hot and afterwards pulverized, forms the plaster of Paris of commerce. It is also found combined with fluorine in the spar of Derbyshire, hence called fluoride of calcium. This is a very beautiful mineral, and is occasionally turned in the lathe into various ornaments.

Phosphoric acid and lime is also found native. Phosphate of lime forms the principal ingredient in the bony structure of all animals.

CALCIUM AND OXYGEN

Combine in two proportions, forming two oxides, the first, or protoxide, being the pure or caustic lime. The peroxide is obtained by passing oxygen gas over the former oxide. The composition of the two may be thus represented :—

Calcium	Oxygen	At. wt.
Protoxide 1 atom 20	+ 1 atom 8	— 28
Peroxide 1 atom 20	+ 2 atoms 16	— 36

Calcium, the metallic base of lime, was obtained by Sir H. Davy in his experiments, performed at the same time with those on the other earths. It is but imperfectly known, and has not, I believe, been obtained by any other chemist. The atomic weight has been estimated—20.

Lime, or the protoxide of calcium, combines with the acids, forming salts, several of which, as in the preceding compounds, are insoluble, as the carbonate, sulphate, and oxalate of lime. The latter acid exerts the strongest affinity for lime of all the acids, and will, consequently, separate it from any other.—(*See Oxalic Acid.*)

On referring to the element carbon, we shall find, under the head of carbonic acid, an experiment shewing the decomposition of carbonate of lime by muriatic acid. If the liquid resulting from this experiment be filtered, and then mixed with a solution of carbonate of potass, (salts of tartar), until the latter ceases to throw down a precipitate, double decomposition takes place, and a carbonate of lime, tolerably pure, is thrown down, which, when washed and dried, is sometimes employed as a constant white, but is far inferior to that obtained from baryta, owing to the density of the latter compound.

Oyster-shells, egg-shells, and even ground-pearls have been employed by some artists as permanent white pigments. They are, however, chemically speaking, all identical with the above compound, and are not superior to it in any one respect.

ALUMINUM.

The pure oxide of the metal aluminum may be obtained by adding to a solution of pure alum a solution of carbonate of potass, until it ceases to precipitate a white mass; this, when well washed and dried, forms pure clay, or the oxide of aluminum. It is a white, insipid, and insoluble powder, forming with water a plastic mass, exemplified in the common clays.

It is found native, in an impure state, and is employed in constructing the various articles of pottery. It differs from most other bodies, in contracting, as heat is applied, by which it receives an additional cohesive force, and was formerly supposed to be infusible, but is now readily fused, by the intense heat of the oxy-hydrogen flame, into a bead of colourless glass.

The protoxide, when recently precipitated from its salts, is readily dissolved by most of the acids; but when it has undergone the action of the potter's furnace, few of them have any action upon it.

The pure oxide of aluminum enters into the composition of several of the precious gems, as the sapphire, the oriental ruby, and topaz.

The metallic base of alumina was first obtained by Sir H. Davy, but in quantities too minute for any accurate examination of its properties. It has since been obtained in larger quantities by Wohler; but even now it has not been so minutely examined as many other bases of the same class. The atomic weight of the metal is stated to be—18.

Alum is an important article to the dyer, from the strong attraction the alumina possesses for the colouring matter employed. This fact will be illustrated under the article, *Vegetable Pigments*.

ALUM.

This is a double salt, composed of the sulphate of alumina and potass. It is extensively manufactured in England from the aluminous slate, which is a compound of alumina and the sulphate of iron. The latter is removed by exposing the slate to the action of a dull red heat, or as it is commonly called roasting the ore, by which process the iron becomes oxidized, and the sulphur converted into sulphuric acid; at the same time combining with the alumina, forming a sulphate, which, by the addition of sulphate of potass, yields, when crystalized, the alum of commerce, the composition of which may be thus represented:—

Alumina.....	3 atoms	54
Potass	1 ditto	48
Sulphuric Acid..	4 ditto	160
Water	25 ditto	225

487 At. wt.

MAGNESIUM.

The oxide of this metal is a compound familiar to all, being the pure, or calcined magnesia of the druggists. It is usually obtained from the decomposition of its sulphate (Epsom salts); this is easily effected, by adding to a solution of the former a solution of carbonate of potass, until it ceases to throw down a white precipitate; this, when washed and dried, and afterwards exposed to the action of a dull red heat for a few hours, is the oxide of the metal magnesium, or calcined magnesia, from which Sir H. Davy obtained the metallic base, the atomic weight of which has been estimated as 12. Magnesia, in many of its properties, bears some resemblance to lime, but with this important difference, that with sulphuric acid it forms a soluble salt, while lime with the same acid, forms an insoluble one.

The oxide of magnesium combines with all the acids forming salts; its composition is as under:

Magnesium	Oxygen	At. wt.
1 atom....	12 + 1 atom 8	= 20

The sulphate and muriate of magnesia are obtained in large quantities from the mother liquor of the sea water, after the common salt is extracted, from which the Epsom salt of commerce is obtained.

Magnesia is found combined with other bodies in several minerals, from which circumstance such bodies are sometimes classed together under the head of magnesian minerals. The principal are, the stealite, or soap-stone, asbestos, chrysolite, &c. &c.

SILICIUM,

Or the base of pure flint, was by Sir H. Davy considered to be a metallic body; and therefore common flint, or rock crystal, was considered a protoxide of the metal; subsequent experiments have, however, thrown some doubt over the above opinion. The point not being yet sufficiently established, we have introduced it among the metals, as it was formerly placed. The elementary principle of common

flint is but of little importance, but the compounds formed by the union of its oxide are very valuable.

Silica, and the preceding elements, enter into the composition of nearly all the precious gems, with the exception of the diamond; it is also an important ingredient in the pigments of the enameller.

The atomic weight of silicium is estimated as = 8, and rock crystal, which is the oxide nearly pure, to be a compound of 1 atom of each of its constituents, thus;

Silicium Oxygen At. wt.

1 atom 8. + 1 atom 8 = 16

The pure oxide of Silicium, as it is sometimes considered to act the part of an acid, has received the name of silicic acid, and is obtained nearly pure from rock crystal; this substance, whether in the state of crystal, flint, or sand, when fused with an alkali, forms glass.

Few acids, with the exception of the fluoric, have any direct action upon silica; by the latter, however, it is readily dissolved: from which circumstance this acid has been employed upon plates of glass, in the same manner as nitric acid is used upon copper-plates, for the purpose of etching, not with a view of taking impressions from it, the etching forming the original picture.

LAPIS LAZULI.

Analysis.

Silica	34
Alumina	33
Sulphur	3
Soda	22
Water	8

100

The mineral lapis lazuli forms one of an important class, called earthy minerals, and it is from this substance the ultramarine is obtained.

The name Lazuli is by some supposed to be derived from

the Arabic word *azul*, or heavens, and is supposed to refer to the deep blue colour possessed by the mineral; on the other hand ultramarine is considered to be derived from the circumstance of this pigment being originally brought into Europe from beyond the sea.

There appears to be little doubt of this mineral being known to the ancients, but of their being acquainted with the pigment produced from it seems very doubtful. As a mineral it was known to the Greeks and Romans, and by them called sapphire. It has also been long known to the nations of the East; and is by many supposed to be the celebrated Armenian blue of the ancients, but without any, I believe, evidence in corroboration of the fact.

In the mineral state it is much employed for ornamental purposes, particularly in China, where it is worn as a badge of honour. The celebrated marble palace in Russia is said to contain an entire apartment inlaid with this mineral.

It is found in Persia, Bucharra, China, Great Tartary, and Siberia; and also in considerable quantities in the island Hainan, in the China sea, from whence it is sent to Canton.

With respect to the colouring matter of this mineral, very little is known. It was formerly supposed that the small quantity of iron obtained from the analysis gave the colour, but this is now supposed to be accidental, and in no way concerned in the production of the beautiful blue colour possessed by the mineral. Iron is always more or less present in the mineral, being frequently in the state of a sulphuret, having the appearance of veins of gold. Lapis lazuli of this description was by the Romans called *sapphirus regius*, under the supposition that the metal was gold. Ultramarine is now manufactured in this country, and the following process will convey an idea of the means employed to obtain it. The stone is brought to a low red heat, and then thrown into water, by which means it is easily reduced to a fine powder; should any portion of the mineral change colour during this process, it should be rejected as bad. The

powder is then mixed with a resinous paste composed of resin, wax, and boiled linseed oil, placed in a linen cloth, and kneaded in warm water; the first product is usually of no value, the second furnishes the finest ultramarine, and the third one of inferior quality.

The pigment thus obtained depends on the singular property of the colouring matter adhering less firmly to the resinous paste, than the earthy matter combined with it, and is therefore pressed through the cloth. Ultramarine is now frequently obtained direct from the mineral, without the application of this resinous paste; the process is said to furnish a much purer specimen. Ultramarine, as a pigment, is of the most permanent order; indeed it would form a good standard by which the other pigments might be estimated in point of durability. Thus, ultramarine might be one extreme of a scale, and the intense scarlet the zero, the relative durability being indicated by numbers decreasing as they recede from the scale of durability.

When ultramarine is brought into contact with any of the mineral or vegetable acids, the colour is instantly discharged; the rapidity with which this change is effected forms no mean criterion of its purity. The French ultramarine, to be mentioned hereafter, is acted upon in a similar manner, but with less rapidity.

As the durability of ultramarine is one of its characteristic properties, and as it is evident no other pigment possesses that quality in so eminent a degree, it must necessarily follow, that when this pigment is introduced into a picture, the others associated with it, will in time become considerably toned down; this not being the case with the former, it will possess all its primitive splendour, and from that circumstance must, I should think, tend to destroy the harmony so important to the good keeping of a picture, so that unless all the pigments be raised to the same standard, or the ultramarine lowered to them, its permanency becomes rather a defect than otherwise.

Ultramarine varies much in purity, depending on the quality of the mineral, and the means employed to obtain the colouring matter; if the lapis lazuli contains much iron, which it not unfrequently does, the action of the fire converts the latter into a peroxide of a deep red colour; this being worked out with the pigment, communicates to it a purple tinge. The sulphuret of iron, by the same process, is converted into a blueish black powder, which would give the ultramarine a dusky hue.

Should the ultramarine be adulterated with cobalt, or any pigment approximating in colour, the acid test will instantly detect it.

This pigment, however, from its high price, is very likely to be superseded by that which follows.

FRENCH ULTRAMARINE.

This compound was discovered by a French chemist, of the name of Guimet, who accidentally discovered a blue vitrification on the hearth of one of his furnaces, and the colour appearing to approach very near that of the lapis lazuli, led him to detach a portion of it, and submit it to the process of analysis; the result of which gave flint, soda, alumina, and sulphur—precisely the same elements found in analysing the lapis lazuli: these, on being mixed, and fused in the proportion indicated by the analysis, the above pigment was produced.

In point of splendour, some specimens shown to me by Messrs. Davy and Son, of Newman-street, seemed very little inferior to that known by the name of the Roman ultramarine. Fears are entertained of its permanency, but not more than all new pigments are subject to, that have not stood the test of years. It may, however, be taken as a general rule, that compounds artificially prepared are seldom of that permanent character with those of the same nature found in the earth. If this be correct, the above compound is a little less durable than the true ultramarine, but if what we then stated

of it be also correct, the artificial pigment is of the most value to the artist.*

CLASS 3.

MANGANESE.

This metal is found in great abundance in the state of an oxide called the peroxide, or more commonly the black oxide, in many parts of the United Kingdom, particularly in Devonshire, Somersetshire, and Aberdeenshire, forming the manganese of commerce.

Metallic manganese is obtained with some difficulty, owing to its great infusibility and affinity for oxygen. The metal is not applied to any useful purpose, its disposition to combine with oxygen, being so powerful as to cause it to combine rapidly with the oxygen of the atmosphere, and crumble into an oxide. When pure, it is of a grey colour, hard and very brittle; its specific gravity is stated to be 8.013, atomic weight 28.

Manganese and oxygen combine in four different proportions, forming three oxides and an acid, thus:—

	Manganese.	Oxygen.	At. wt.
Protoxide	1 atom 28	+ 1 atom 8	= 36
Deutoxide	1 ditto 28	+ 1½ ditto 12	= 40
Peroxide	1 ditto 28	+ 2 ditto 16	= 44
Manganese acid . .	1 ditto 28	+ 2½ ditto 20	= 48

Of the above compounds the peroxide is the only one extensively employed in the arts. The peroxide is usually in the form of small granular masses, of a deep brown or black colour. When heated with muriatic acid, it is decomposed,

* Since the above was written, I made a rough analysis of a very fine specimen of French ultramarine, obtained from the house of Messrs. Davy and Son, and found it to consist of iron, sulphur, silica, alumina, and soda; the iron was, however, in much greater abundance than I had reason to expect, from which I should say, its colour depends upon this metal, or its oxide; and if the recent analysis of the true ultramarine be correct, it differs very materially from it in composition.

together with a portion of the acid, the oxygen of the oxide combining with the hydrogen of the acid, to form water, while the chlorine is liberated.

The uses to which the native peroxide is put are numerous, in addition to that of furnishing the bleacher with chlorine. It is extensively employed in the manufacture of glass, from the circumstance of its clearing the gross matter from the frit or rough metal. It is by the workmen frequently termed glassmakers' soap. In the potteries it is employed as a cheap brown enamel for the common pottery, by the dyer as a pigment in cotton printing, and by the chemist for obtaining oxygen gas.

MANGANESE BROWN.

The hydrate * of the deutoxide forms a very valuable brown pigment for the artist, and is said to dry well in oil. The common peroxide should never be employed, being frequently associated with chalk, barytes, the oxides of iron, and other metals. It may be obtained tolerably pure by dissolving the native peroxide in muriatic acid until chlorine ceases to be evolved, being careful to avoid the fumes given out, which should be allowed to pass up the chimney of the apartment. When the action has subsided, the whole must be thrown on a filter. To the clear liquid, add a solution of pure potass, until it ceases to throw down a white precipitate, which must be well washed and permitted to dry spontaneously, turning it frequently, that all parts may be acted upon by the atmosphere. The white powder thrown down is the protoxide; but by exposure to the atmosphere it absorbs oxygen, and is converted into the deutoxide or manganese brown.

CHROMIUM.

This metal was discovered in 1797 by Vauquelin. It received the name chromium from the variety of colours it produces by its union with the metallic oxides, &c. It is obtained with some difficulty, in consequence of its great infusi-

* The term hydrate is intended to signify the combination of a body with water; thus, slaked lime is a hydrate of the protoxide of calcium.

bility, from which circumstance the metal has been but little examined. When pure it is of a grey colour, somewhat resembling iron, having a specific gravity of 5.9. Its atomic weight is stated to be 28.

Chromium and oxygen combine in two proportions, forming an oxide and an acid.

	Chromium.	Oxygen.	At. wt.
Protoxide . . .	1 atom 28	+ 1½ atom	= 40
Chromic acid . .	1 ditto 28	+ 3 ditto	= 52

CHROME GREEN.

The protoxide of chromium, when pure, is of a green colour, and to the artist forms an invaluable green pigment, as the atmosphere or any other body appears to have but little effect upon it; contrary to the other pigments of the same colour, which are powerfully acted upon by light and moisture, this is of the most permanent order.

It is readily prepared by decomposing a solution of nitrate of mercury by chromate of potass. An orange chromate of mercury being thrown down, this, when washed and dried, and afterwards submitted to a red heat, changes by the volatilization of the mercury, and the loss of a portion of the oxygen of the acid, into the green protoxide or chrome green.*

The emerald is said to be indebted to this oxide for its green colour. When fused with glass it communicates to it a grass green colour, forming a valuable green pigment for the enameller.

CHROMIC ACID.

An orange compound of the chromate of lead was discovered by Scheele, some time before the true nature of the compound was understood, in examining some specimens of the red lead ore of Siberia; his experiments led him to conclude, that the yellow colour was caused by some acid in union with the lead, not then known to chemists. The

* This must not be confounded with a chrome green, which is a very inferior pigment, being generally a compound of the Chrome Yellow and Prussian Blue.

acid, which at first could only be obtained in small quantities, was afterwards examined by other chemists, and eventually Vauquelin, in 1797, pronounced the acid to be a new metal in combination with oxygen, forming a metallic acid.

CHROMATE OF POTASS,

Is prepared in the large way by fusing together 4 parts of the native chromate of Iron with 1 of nitrate Potass, (saltpetre). The mass, after being kept at a strong red heat for some hours, is permitted to cool, water is then added to wash out the soluble chromate of Potass formed by the decomposition of the native chromate of Iron.

Chromate of Potass is generally in the form of crystals of a bright lemon colour, having a specific gravity of 2.6, and is very soluble in water; it is this salt which, by double decomposition, furnishes the great variety of chrome colours now so extensively employed by the artist; it consists of:—

Protoxide of Potass	Chromic Acid	At.wt.
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1 atom	48+1 atom	52 = 100
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BICHROMATE OF POTASS,

Is formed by adding to a solution of the preceding salt a sufficient quantity of sulphuric acid to render it slightly acid, and setting it aside for a few days, the sulphuric acid, by combining with a portion of the Potass, converts the remaining chromate into the bichromate, which falls down in ruby-coloured crystals, consisting of 1 atom of Potass and 2 atoms of Acid. At.wt. 152.

IRON.

This metal, which occasionally is found native, is when pure of a grey colour, having a specific gravity of 7.77. When at a bright red heat it possesses that important property which is termed welding. At very high temperatures it is, in common with the other metals, combustible, the result of the combustion is an oxide of the metal.

Pure Iron is attracted by the magnet, but cannot be made to retain magnetism, unless it is combined with carbon, forming steel.

The ores of Iron are numerous, the principal of which are the oxides and the sulphurets; the latter are generally called Iron pyrites.

Iron and oxygen unite in two proportions, forming the protoxide and peroxide of the metal. The atomic weight of Iron is estimated at 28.

	Iron	Oxygen	At.wt.
Protoxide....	1 atom 28	+ 1 atom 8	= 36
Peroxide	1 atom 28	+ 1½ atom 12	= 40

The protoxide of Iron is of a black colour, possessing in the mass a faint metallic lustre; it is best obtained by passing steam over fragments of the metal, heated to redness in an earthenware tube, the steam being decomposed, its oxygen combines with the Iron to form the protoxide, the hydrogen being set free.

Peroxide of Iron is generally of a red or deep brown colour, it may be obtained tolerably pure by decomposing a solution of sulphate of Iron, (green copperas) with any of the alkalis: this when washed and dried at a low red heat, becomes converted into the brown, or peroxide. The ochres, and other ferruginous earths, are indebted to this oxide for the colour they possess.

Iron combines with chlorine in two proportions, forming the protochloride and perchloride of Iron; with sulphur it combines in three proportions, forming the sulphuret, bisulphuret, and sesquisulphuret of Iron; with Iodine in one proportion, forming the Iodide of Iron; it combines also with phosphorous and carbon. The latter compound is of considerable importance in the arts, forming that valuable material steel.

PLUMBAGO, OR BLACK-LEAD,

Is generally considered a true carburet of Iron; it is a native compound, the best specimens of which are obtained from Borrodaile, in Cumberland; it is infusible, and is combustible only at a very high temperature. Plumbago is ex-

tensively employed in the manufacture of pencils for the artist. As a certain quantity, only of the best description, is annually dug, it maintains a high price, and thus numerous frauds are practiced by the inferior manufacturers. Sulphur and the common sulphuret of antimony are frequently combined with the dust, &c. from which the common cheap pencils are manufactured.

STEEL.

This important and valuable compound of Iron and Carbon is generally obtained by placing bars of the best description of Iron in contact with charcoal, and exposing them to the action of a red heat, by which process the Iron absorbs a small portion of Carbon, animal charcoal, or a mixture of the two being generally preferred by the manufacturers. This first process, which is commonly called cementation, affords a kind of steel called blistered, this, when beaten out and afterwards drawn into bars, passes under the name of tilted steel; the latter, when welded together, and again drawn into bars, is called shear steel.

Steel plates have recently been introduced for the engraver in lieu of copper, the former, by their extreme hardness, affording a greater number of impressions from the same plate. Some difficulty, however, appears to exist in obtaining steel adequate to the purpose, the principal inconvenience being experienced in the technical process of biting in the plate, that is in dissolving by some corrosive liquid certain lines traced out by the graver; much uncertainty depending as to the success of the process. It appears, by experience, that the direct action of an acid when employed in a similar manner to the nitric acid (aqua fortis) on the copper plate, does not succeed so well as when a compound is employed, as some metallic salt, the acid of which possesses a superior affinity to combine with the Iron of the steel, thus the salts of Copper and of Mercury have been

made use of for this purpose. The following preparation affords, I believe, a compound that is now employed by several eminent engravers.

Bichloride of Mercury (corrosive sublimate) ½ oz.

Refined alum ½ oz.

Boiling distilled water 8 oz.

Mix and dissolve, filter the whole, and apply it as usual.

The oxides of Iron, combine with the acids, forming a class of salts possessing a styptic taste, affording by the addition of a decoction of galls a black colour. The salts of Iron containing the peroxide are readily distinguished from those of the protoxide, by the former giving out a deep blue colour, and the latter a white or light blue, or grey, by the addition of a solution of the ferrocyanuret of potass, (prussiate of potass.)

PRUSSIAN BLUE (Ferrosesquicyanuret of Iron.)

This beautiful pigment was accidentally discovered early in the last century by Diesbach, a colour maker at Berlin; the mode employed in its preparation was not made public until the year 1724. At the present time it is manufactured in very large quantities in this country.

The Prussian Blue of commerce is usually prepared by fusing in iron pots, equal parts of pearlash (carbonate of potass), and any convenient animal matter, as the horns and hoofs of animals, dried blood, or even leather shavings: the mass swells up, liquifies, and finally becomes quite dry, the whole being continually kept agitated by stirring it with iron spatulas; to the mass, when cool, water is added, to wash out the soluble parts; this after being allowed to clear itself, is drawn off, and then mixed with one part of sulphate of Iron and two of alum, by the addition of which a dirty green precipitate is thrown down; it is then separated from the supernatant liquor, and repeatedly washed with weak hydro-chloric acid, (spirits of salt), finally changing by the absorption of oxygen, into the pigment Prussian Blue.

The chemical changes resulting from this process are, perhaps, the most complicated of any in the whole range of chemical affinities. The following rough outline may, serve to convey an idea of the alterations which take place in the nature of the compounds employed. The animal matter consists of carbon, oxygen, hydrogen, and azote, the carbonate of potass of potassium, oxygen, and carbon; by the action of heat the various elementary principles are liberated, the azote and carbon unite to form cyanogen, (which see.) This again unites with the potassium, forming cyanuret of potassium; other compounds are formed, not essential to the production of the pigment, some of which are liberated in the form of gas. Upon the addition of the water, the cyanuret of potassium is dissolved, and by the further addition of the sulphate of iron, the cyanogen quits the potassium to combine with the iron, forming the insoluble ferrosesquicyanuret of iron, or prussian blue. By a process differing slightly from the preceding, an amber coloured salt is obtained, forming beautiful tables or plates of crystals, called ferrocyanuret of potass, from which compound Prussian Blue should always be manufactured for the artist. The following process I find to answer extremely well:--

Exp.—Dissolve the peroxide of iron in hydro-chloric acid until the latter ceases to act upon the oxide, then add to it an equal quantity of water, and throw the whole on a filtre; to the clear liquid add a solution of the ferrocyanuret of potass until it ceases to throw down a dense blue precipitate; separate the latter from the supernatant liquid, and wash it with dilute hydro-chloric acid, and afterwards with distilled water; this when dried at a moderate heat, affords a very pure specimen of Prussian Blue.

HYDRO-CYANIC ACID.

When one part of the peroxide of mercury, and two of prussian blue, are boiled together in eight parts of water, the

prussian blue is decomposed by the cyanogen entering into combination with the mercury ; the whole must be thrown while hot on a filterer—a clear liquid passes through, holding the cyanuret of mercury in solution, which is deposited as the liquor cools, in the form of yellowish white crystals, of a very poisonous nature. The latter compound when decomposed by hydrochloric acid, affords hydrocyanic (prussic) acid, and chloride of mercury.

As the base of prussic acid was originally obtained from animal matter, as dried blood, &c. some are apt to imagine that it exists in that state in the blood ; it would, I think, be needless to point out the absurdity of such an idea.

The true position of this compound, with respect to the animal matter employed in its production is, simply—that the elements of the latter being liberated by the action of the heat, are again free to unite, certain affinities are again brought into action, which disposes the elements at the moment of their liberation, to unite in certain definite proportions, new compounds are produced, of which the compound base of prussic acid is one, being when resolved into its ultimate elements a compound of carbon and nitrogen. —(*See Cyanogen.*)

Prussian Blue forms a very beautiful, and by no means fugitive pigment ; it is objected to by some artists, upon the fact of its scaling up when mixed with other pigments, more particularly with Indian ink ; I am, however, inclined to consider this fault in a great measure, to be owing to the impurity of the pigment employed.

NATIVE PRUSSIAN BLUE.

This compound is not as its name would imply, similar in composition to the preceding, but is a native phosphate of the protoxide of iron ; it is occasionally found crystallized, having but little resemblance to the true pigment, whose name it bears ; it is sometimes found associated with the iron pyrites of Cornwall.

ANTWERP BLUE,

Differs from Prussian Blue simply in containing the earth alumina, by which it is rendered lighter in colour; it may be obtained by precipitating the base of Alumina, (which see), and afterwards mixing with it the prussian blue until the required tint is obtained.

GERMAN BLUE.

The author has lately succeeded in obtaining another pigment, to which the above name has been given, an oxide of antimony being made to supply the place of the alumina in the preceding; in tint, it occupies a middle place between Antwerp Blue and Ultramarine. Some of it is now in the possession of Messrs. Davy and Son, for trial. It possesses a rich purple tint, and is, I should consider, equally as durable as the Prussian blue.

THE OCHRES.

Are native earthy productions, the colouring matter of most of them depending upon the presence of iron in various states of oxidizement; their colour is also supposed to be modified by the arrangement of their parts—among the principal of this class we have—

Red Ochre	Stone Ochre
Yellow Ditto	Roman Ditto
Venetian Red	Oxford Ditto
Light Ditto	&c. &c.

Light red and Venetian red are not unfrequently artificial productions, the former being obtained by calcining the native yellow ochre, the latter from sulphate of iron; in some places, this salt is submitted to distillation, with a view to obtain the sulphuric acid; after the latter ceases to be given off, there remains in the retort a red, earthy-looking powder, in commerce passing under the name of colcathar, or plate rouge.

UMBER.

Is another variety of native oxide of iron, containing also oxide of manganese. It is found principally in the isle

of Cyprus; and varies in colour, from a clove-brown to a blackish, or yellowish brown.

Burnt Umber is simply the above mineral submitted to the action of heat, by which process oxygen is absorbed, and its colour deepened. Umber is not unfrequently confounded with a substance called earthy-coal, of bituminous origin.

Raw Sienna, like the preceding, is a compound of earthy matter, and oxide of iron. By long exposure to a red heat, the iron it contains imbibes more oxygen; it then passes under the name of burnt sienna.

The native ochres are generally of the most permanent order, and have been used in all ages, and by all nations. The old masters are said to have employed them freely.

LEAD.

The native compounds of lead are very numerous, consisting of the metal and its oxides, in combination with various mineralizing agents. Thus we have the native oxides, sulphurets, chromate, arsenite, and carbonate of lead, &c. The most abundant ore of this metal, and that principally employed to obtain the lead of commerce is the sulphuret, or galena.

Pure lead is of a bluish white colour, of a specific gravity of 11.4. It melts at 612° at which temperature it rapidly absorbs oxygen, passing into the state of an oxide. Lead and oxygen are said to combine in four different proportions, some doubt however exists as to the last oxide being a definite compound. The atomic weight of lead is 104. The following table will represent the quantity of oxygen and base in these oxides:—

	Lead	Oxygen	At.Wt.
Protoxide.....	1 atom = 104	+ 1 atom 8 = 112	
Deutoxide	1 ditto = 104	+ $1\frac{1}{2}$ ditto 12 = 116	
Peroxide	1 ditto = 104	+ 2 ditto 16 = 120	
Dioxide.....	2 ditto = 208	+ 1 ditto 8 = 216	

Protoxide of lead is of an orange yellow colour,* and is readily obtained by submitting to the action of a dull red heat the artificial nitrate, or carbonate of lead. During the process the acid is driven off, leaving the metal in the state of a protoxide, which is the only one of the oxides which enters into combination with the acids.

This oxide is extensively manufactured for commercial purposes by exposing the grey powder or dross, which forms on the surface of melted lead, to the further action of heat and air, in which state it is known by the name of massicot. This at a high red heat fuses, and on cooling takes the form of small reddish brown scales, and it then passes under the name of litharge.

The protoxide, in common with all the oxides of lead, is readily reduced to the metallic state by heating it in contact with charcoal.

DEUTOXIDE (Red Lead : Minium.)

Is obtained by a still further exposure of the preceding oxide, to the action of heat and air, care being taken not to permit the temperature to be sufficiently high to cause the fusion of the mass. During this process, a further dose of oxygen is absorbed, and the protoxide passes into the deutoxide, or red lead, which, from its atomic composition, is by some chemists regarded as a sesquioxide.

The deutoxide is sometimes found native, but is seldom sufficiently brilliant in colour to be employed as a pigment; it occurs in masses, and in the state of powder, in Germany, France, and Yorkshire, associated with clay, and sulphuret of lead.

The red lead of commerce is manufactured in large

* I received a sample of this compound bearing a brilliant orange yellow colour, from an eminent artist, who informed me that it could be obtained only from France, and was desirous of knowing its composition. In colour it approaches very near to the Iodide of Lead, but although by no means a permanent body, it is yet infinitely more so than the latter. It passes under the name of Golden Yellow.

quantities, which seems to be necessary, to ensure brilliancy of colour; it appears to have been extensively known to the ancients, but whether the red lead employed by them was a natural or artificial production, admits of some doubt. The minium of the ancients is now generally supposed to refer to vermilion, and not to the red lead, or minium, of the moderns.

This pigment, as at present manufactured, is certainly very far from being of a permanent order, but many of the paintings executed by the ancients, in which this compound has been freely employed, although bearing evident traces of great antiquity, as in those found during the recent excavations at Pompeii, are yet as brilliant in colour as if the work was fresh from the artist's pencil. In some experiments that I have made, I find that red lead will not stand with any of the following pigments:—

Vermilion,	Chrome Orange (Mercury).
Greens (with a copper base),	Orpiment.
Intense Scarlet,	Patent Yellow.
White (with a base of lead),	King's Yellow.
Chromes,	ditto

Sulphuretted hydrogen acts very powerfully on the oxides, and other compounds of lead, converting them into hydro-sulphurets of the metal.

The peroxide of lead is of a deep brown, or puce colour, and the dioxide of a grey colour. Neither of them has been applied to any useful purpose.

CHLORIDE OF LEAD.

Lead and Chlorine combine, forming a white chloride of lead; this when fused and cooled, bears some resemblance to horn; (hence it received the name of *plumbum corneum*.) It is composed of one atom of chlorine, and one of lead as:—

	Lead	Chlorine	At. wt.
Chloride of lead....	1 atom....	104 + 1 atom	36 = 140

PATENT YELLOW, OR TURNER'S PATENT YELLOW.

A yellow compound of the chloride and oxide of lead, passing under the above name, is manufactured in the large way, from a new method of preparing it by the patentee; there are two processes for obtaining it, distinguished by the terms humid and dry. The former consists in mixing common salt and litharge, moistened with water; the common salt, after a time being decomposed, the chlorine combining with the lead, forming an insoluble chloride, leaving the soda in solution; the latter is then separated from the former by washing, and the chloride fused and pulverised. The dry process is simply fusing the litharge and common salt, and afterwards washing out the soda.

The following process, I find, affords this pigment in its greatest purity, and is one that I would recommend when the compound is intended for the use of the artist; it is not so economical as the preceding, and, therefore, would not answer on the large scale for commercial purposes.

Take 10 parts of clean and well washed litharge, and 1 of muriate of ammonia, (sal ammoniac), grind them well together, and submit them to the action of a dull red heat in an iron crucible, until the ammonia ceases to be evolved; the fire must then be urged until the mass enters into fusion; the crucible may then be removed from the fire; the mass when cool must be pulverized, and well washed with distilled water, and dried.

Patent Yellow, as a pigment, is inferior in brilliancy to the chromes, nor am I aware that its permanency is in any way superior.

CARBONATE OF LEAD, (White Lead: Ceruse.)

Carbonic acid and the protoxide of lead combine, forming a white insoluble carbonate of lead, consisting of 1 atom of each of its constituents, as—

Protoxide of Lead Carbonic Acid At.wt.

Carbonate of lead 1 atom 112 + 1 atom 22 = 134

The old mode of obtaining it for commercial purposes was by exposing coils of sheet lead to the united action of the vapour of vinegar and the atmosphere, by which the lead was first oxidized, and then converted into a carbonate; as soon as a sufficient deposition had formed on the surface of the plates, it was removed, and the coils again submitted to the same process. It may also be obtained by double decomposition, from the nitrate, or acetate of lead, by any alkaline carbonate, for which process Mr. Hemming has lately taken out a patent. For the artist this latter mode should always be employed, as follows:

Make a saturated solution of the acetate, or nitrate of lead, to which add a saturated solution of carbonate of potass until it ceases to throw down a white precipitate, which must then be thrown on a filter, and well washed with distilled water, and dried.

Carbonate of lead has received an endless variety of names, depending on the place, or of some peculiar method in its manufacture, hence we have Nottingham, Creams, Flake, white, &c. It is, when properly prepared, a very beautiful pigment, possessing a good body, and drying well either in oil or water; but from the action of sulphuretted hydrogen, which is more or less present in apartments usually devoted to the reception of paintings, it is very prone to change colour.

SULPHATE OF LEAD.

If a dilute solution of sulphuric acid, (oil of vitriol), be substituted in the last process for the alkaline carbonate, a dense white insoluble sulphate of lead is thrown down, which, when treated in the same manner, affords a very beautiful white pigment.

CHROMATE OF LEAD, (Chrome Yellow.)

There are two distinct compounds of this acid and of the protoxide of lead, the one having a fine yellow colour, and the other a red, of a tint between vermilion and the iodine scarlet.

The manufacturers of these compounds, however, by slightly varying the process, obtain a variety of coloured chromes possessing an intermediate tint between the two above noticed, which pigments appear to be merely mixtures of the chromate and dichromate, producing the orange chromes.

CHROME YELLOW;

Is readily obtained by adding to a solution of the acetate, or nitrate of lead, a solution of chromate of potass; double decomposition takes place, and the yellow chromate of lead is precipitated; this, after being well washed and dried, forms the chrome yellow, consisting of 1 atom of the protoxide $112 + 1$ atom of the acid $52 = 164$ At.wt.

DICHROMATE OF LEAD, (Chrome Red.)

This compound forms a very beautiful orange-red colour, and is certainly one of the most permanent of the chromes of this class; it is easily prepared by boiling the above chromate in a solution of caustic potass, by which process a portion of the chromic acid is transferred to the potass, leaving the remaining portion in the state of a dichromate, or as it is sometimes called, a subchromate of lead, consisting of 2 atoms of the oxide, $224 + 1$ of acid, $52 = 276$. This pigment I find is but little known to the artists generally; those to whom I have shown samples of it, consider it would, with white, form a very beautiful flesh tint, but I much fear its permanency if the white employed should have lead as a base. These are the only two compounds of chromic acid and the protoxide of lead acknowledged as distinct compounds by the chemist; there are, however, various chrome pigments of this class which differ in point of colour very decidedly from each other, and as before observed, they are mixtures only of the red and yellow chromate, the two simple colours producing a variety of compounds, tints of an orange cast depending for colour, of course, upon the quantity of either employed;

hence arises that difficulty of producing two samples of the same pigment made by two different houses, or even by the same house at different times, of precisely the same tint. They are not obtained by the manufacturer from the direct admixture of the two, and therefore I am inclined to think that the artist would find it more convenient to form the required tint upon his pallet from them, than to depend upon the varied success of the manufacturer.

The chromes generally, are a class of pigments with which speculation has been busy as to their probable durability. Thus I have heard some artists condemn them most severely, and I have heard others speak as highly in their praise. To assert that their permanency is equal to ultramarine would be absurd, neither are they as permanent as the native ochres; but, on the other hand, they are certainly as stable, if not more so, than the Patent, King's, and Naples yellows, and considerably more so than those obtained from the vegetable kingdom. I cannot see, therefore, comparing them with the other chemical compounds, why they should be considered more fugitive.

IODIDE OF LEAD, (Iodine Yellow.)

Iodine and lead unite, forming, perhaps, one of the most brilliant yellow pigments; unfortunately, however, it cannot be made available to the artist, owing to its fugitive nature, the mere exposure to day-light effecting its decomposition. It is easily prepared by adding a solution of hydriodate of potass, (Iodide of Potassium) to a solution of the acetate, or nitrate of lead; the iodide of lead falls down, composed of one atom of lead, 104 + to 1 atom of iodine 125=229 At.wt.

Taking the pigments formed from this metal collectively, they present, perhaps, with the exception of some of the compounds of mercury, the most fugitive order of the whole class, owing to the powerful affinity exercised over them by sulphuretted hydrogen.

MERCURY.

This metal is occasionally found native, but the principal source from which it is obtained is the sulphuret, or native cinnabar.

Mercury, or quicksilver, is the only metal that remains fluid at the common temperature of our atmosphere; it can, however, be made to assume the solid state by exposing it to an intense degree of cold. It is stated by some of the more recent voyagers to the arctic regions, that the temperature there is sufficiently low to effect this without any artificial application; the degree at which it becomes solid being -40° , that is 40° below zero. At a temperature of 670° it boils, and flies off in vapour; hence distillation is one of the modes of purifying it, the impurities being left behind in the retort. At 60° the specific gravity of mercury is 13.5. The atomic weight is, as is the case with many other of the elements, variously stated: 200 however, is the one most generally acknowledged.

Mercury and oxygen combine in two proportions, forming the protoxide and the peroxide, as:—

	Mercury	Oxygen	At.wt.
Protoxide,.....	1 atom 200	+ 1 atom 8	= 208
Peroxide	1 ditto 200	+ 2 ditto 16	= 216

The protoxide of mercury is of a black colour, and may be obtained by adding to the protochloride of mercury, (calomel) a solution of pure potass in excess, and triturating the mass for some time; it is then to be well washed with cold water, and dried in a dark place.

PEROXIDE OF MERCURY,

Is of a bright red colour, and, as usually obtained, is in the form of small brilliant red scales, with a tinge of yellow; there are two processes for obtaining it. The following is, however, the one which affords the finest specimen:—

Place in a flat glass vessel, terminating in a long neck, a sufficient quantity of pure mercury to cover the bottom, the bottle and mercury is then to be placed in a sand bath, the temperature of which must be retained at 500° until the change is effected. During the process, which generally occupies about a month, the mercury, assisted by the heat, combines with the oxygen of the atmosphere passing into the red peroxide.

MERCURY AND SULPHUR,

Combine in two proportions, forming the protosulphuret and bisulphuret of mercury, their atomic composition is as follows :—

	Mercury	Sulphur
Protosulphuret...	1 atom 200	+ 1 atom 16 = 216
Bisulphuret	1 ditto 200	+ 2 ditto 32 = 232

The protosulphuret of mercury is of a black colour, and may be obtained by passing a stream of sulphuretted hydrogen through a dilute solution of the protonitrate of mercury, by which process a protosulphuret of mercury is precipitated.

BISULPHURET OF MERCURY, (Vermilion.)

This compound of mercury and sulphur is found native in considerable quantities, furnishing the principal source from whence the mercury of commerce is obtained; it is seldom, however, sufficiently pure in colour to be of much use to the artist.

Native vermilion, or cinnabar, is found in Europe in the mines of Hungary, France, and Spain. In Asia, in those of Siberia and Japan, and also in some parts of South America; the mines of Almaden are, however, the most productive, affording occasionally native mercury and native amalgam of silver.

The vermilion of commerce is an artificial production which is manufactured in considerable quantities in Holland, passing in this country under the name of Dutch vermilion. There is also another vermilion, commonly sold

under the name of the Chinese, but which differs from the preceding in being commonly a sulphuret of arsenic instead of mercury. The Chinese have however a native vermilion of considerable purity, the consumption of which in this country is very limited compared with the former.

The manufacture of vermilion, on the large scale, is usually effected by triturating in a mortar eight parts of mercury with one of sulphur, until the whole is reduced to a black powder; a moderate heat is afterwards applied to obtain a more immediate union of the sulphur with the mercury; the mass is then removed to the subliming pots, and sublimed. The sublimate, when reduced to powder, affords the vermilion. As a pigment, vermilion is but little acted upon by exposure to air or moisture, light, however, is known to effect its decomposition by reviving the mercury, giving to the parts so acted upon the appearance of having been silvered.*

Vermilion was in great repute with the ancients, by whom it was called minum, but whether the pigment employed by them was a natural or an artificial production, is at this period uncertain. The probability is, however, in favour of the former, from its retaining its brilliancy for so long a period.

The vermilion of commerce is frequently adulterated with red lead, a fraud that may be easily detected by placing a small quantity of the suspected pigment upon a piece of red hot iron; if pure, the vermilion is entirely volatilized; should, however, any residue be left, it is adulterated.

FIELD'S EXTRACT OF VERMILION.

When vermilion is ground up with water and allowed to stand at rest for a few minutes, it separates into two distinct portions, the one floating over the other, forming a kind of cream of a fine orange colour. Mr. Field has ingeniously separated the two, the latter of which he has introduced as a pigment under the above name. I have not

* The author had an opportunity of examining a modern picture a short time since in which this change had taken place.

had an opportunity of submitting it to the test of analysis, but I consider it owing to the presence of a small quantity of the subsulphate of mercury, which, during the process of manufacturing the vermilion, is frequently a spontaneous formation. The latter compound, when separately prepared, being of a fine yellow colour, but in this instance, being mixed with the vermilion, the latter communicates to it an orange tinge. If this view be correct, and I have every reason to believe it to be so, the expense of the process, and the high price of the compound when obtained, might be considerably reduced by the direct admixture of the two, at the same time I have much fear of its durability; the various salts of mercury being readily decomposed by these agents, which, as pigments they are more or less exposed to.

SUBSULPHATE OF MERCURY, (Queen's Yellow)

Is the compound mentioned in the preceding article, and may be obtained by boiling to dryness 5 parts of sulphuric acid with 4 of mercury; a white crystalline persulphate of mercury is obtained: this when thrown into water undergoes decomposition, being resolved into a soluble supersulphate and an insoluble subsulphate, which is precipitated, forming when washed and dried the pigment Queen's Yellow; it is far from being a permanent pigment.

CHROMATE OF MERCURY, (Orange Chrome)

Is readily obtained by adding to a solution of the nitrate of mercury, a solution of chromate of potass, until it ceases to throw down an orange precipitate. This, when prepared in the usual way, furnishes a pigment beautiful in colour, but one that is readily decomposed; its principal use is in affording the chrome green.—(which see.)

IODIDE OF MERCURY.

There are two compounds of Iodine and Mercury, forming the protiodide and the periodide, one of a fine yellow colour, and the other of a brilliant scarlet; the colours of these two compounds are of a most beautiful order, but so prone are they to undergo decomposition, that the mere ex-

posure to the direct rays of the sun is sufficient to effect their entire change. Their atomic constitution is as follows:

	Mercury		Iodine	
Protiodide	1 atom	200	+	1 atom 125 = 325
Periodide	1 ditto	200	+	2 ditto 250 = 450

Protiodide of Mercury, may be obtained by adding a solution of the Iodide of Potassium to one of the Protonitrate of Mercury, the protiodide is thrown down, and is, when carefully prepared, of a greenish yellow colour.

The Protiodide is obtained pure with some difficulty, depending upon the protonitrate of mercury employed; should the latter contain the peroxide, the colour is then of an olive brown.

PERIODIDE OF MERCURY, (Intense Scarlet)

Is obtained in a similar manner to the preceding by substituting the bichloride for the nitrate of mercury, care being taken not to add more of the iodide than is sufficient to effect the purpose, the precipitate being re-dissolved by an excess of the iodide of potassium.

The periodide of mercury, or the intense scarlet is, I believe, employed by some artists, but I cannot imagine they are aware of its fugitive nature.

MERCURY AND CHLORINE

Combine in two proportions, forming the two important compounds, calomel and corrosive sublimate, the former being the chloride and the latter the bichloride of mercury, or as they are frequently denominated, proto and perchloride.

With the exception of the bisulphuret, or vermilion, there are few of the compounds of mercury that can be depended upon by the artist, and I think it would be well were they entirely discarded from the list of pigments.

COPPER,

Is sometimes found native in a variety of forms, frequently crystallized in cubes and octoëdra.

It is a dull red metal, but it can be made to receive a very brilliant polish, which, however, does not remain permanent, in consequence of the formation of a thin film of oxide on the surface when exposed to the action of air and moisture. It is exceedingly ductile and malleable, and when rubbed by a warm hand gives out a peculiar odour; it requires a high temperature to effect its fusion, but less so than gold; when intensely heated it burns with a brilliant green flame; pure copper has a specific gravity of 8.86; the atomic weight is estimated at 32 by some chemists, and at 64 by others.

The principal ores of this metal are the oxides, sulphurets, carbonates, and arseniate of copper; the sulphuret is the most abundant, and the one principally employed in this country to obtain the metal. These occur in various parts of the globe, but chiefly in the mines of Hanover, Saxony, Sweden, America, and Cornwall.

COPPER AND OXYGEN

Are stated to combine in two proportions; the first compound is not generally considered as a definite oxide; it is said to consist of 2 atoms of copper and one of oxygen. The atomic proportions are,

	Copper	Oxygen	At. wt.
Dioxide..	2 atom 64	+ 1 atom 8	— 72
Protoxide	1 atom 32	+ 1 atom 8	— 40

The dioxide of copper is frequently found native; it is not formed by the direct oxidisement of the metal, but by the extraction of oxygen from the protoxide: when acted upon by an acid, it is resolved into the protoxide and metallic copper; it is occasionally employed in the bronzing of copper vessels, to which it communicates a brown colour.

Protoxide of copper is of a black colour, and is the only oxide which unites with the acids to form the salts of copper. When plates of copper are made red hot, and then struck with a hammer, the protoxide which is formed on the

surface is detached in small black scales. When fused with vitreous compounds, it communicates to them either a green or a blue tint.

In a paper read before the Royal Society, by Sir H. Davy, on the nature and properties of the pigments employed by the ancients, he very satisfactorily proved both by the analysis of the original compound, and the synthetical formation of it, that the beautiful blue pigments so prominent in the ancient paintings, more particularly those found in the ruins of Pompeii, are indebted to this oxide for their colour, prior to which examination the colour was supposed to be owing to cobalt.

COPPER AND SULPHUR.

There are two compounds of sulphur and copper, the one being the disulphuret, and the other the sulphuret, both of which are found native, the latter, however, is the most abundant, forming the principal of the copper ores. The composition of the two is thus represented.

	Copper	Sulphur
Disulphuret	2 atoms 64	+ 1 atom 16 = 80
Sulphuret	1 atom 32	+ 1 atom 16 = 48

The disulphuret of copper may be formed artificially by heating in a Florence flask a mixture of copper filings and sulphur, when the latter is fused, the two bodies immediately rush into union, which is accompanied by a vivid action, with the production of light and heat. The compound formed is a black brittle mass.

SULPHURET OF COPPER,

Forms the principal of the copper ores, furnishing the metallic copper of commerce; it always contains a variable quantity of iron, hence it is frequently denominated ferrosulphuret of copper: it not unfrequently contains also lead and arsenic; it cannot, as the preceding, be formed artificially.

CARBONATE OF COPPER, (Mineral Green.)

This is a compound, as its name implies, of the protoxide of copper and carbonic acid; for the purpose of the artist the following mode may be adopted to obtain it:— Dissolve in boiling water as much of the sulphate of copper, (blue vitriol) as the water is capable of taking up; while still warm add to it a solution of the carbonate of potass, (salt of tartar) until it ceases to throw down a green precipitate; throw the whole on a filter, and wash it with boiling water: the latter process greatly improves the tint. This compound is occasionally found native, passing when massive under the name of malachite, and when in a pulverent state under that of chrysocolla, or mountain green. The native compounds of carbonate of copper are of a light blue or green colour, the former of which are occasionally found in Cornwall, but more frequently in the Uralian Mountains of Siberia; the latter or blue carbonate, which is frequently called mountain blue, occurs principally in Saxony and Bohemia, and occasionally in Chessy, near Lyons.

BLUE VERDITER,

Is an inferior pigment, and being frequently manufactured from the blue solution of nitrate of copper, left after the process of silver refining, is commonly called refiner's verditer. The following process I find to be one of the best for obtaining it:—

Dissolve copper filings in dilute nitric acid, (aqua fortis) by a moderate heat, until the acid is saturated; add an equal quantity of water to the solution obtained, which is a nitrate of copper, and proceed to precipitate the oxide of copper by adding small quantities of caustic lime, until the green substance ceases to be precipitated, or until the liquor has lost nearly all its blue colour; throw the whole upon a filter and well wash the precipitate; to which, when nearly dry, must be added from 8 to 10 per cent. of fresh caustic lime, incorporating the whole well together. During the latter process the previous green colour will be converted

into a blue, forming the pigment verditer. It is, however, but a very uncertain colour, and is, I believe, but little employed by artists at the present day.

FERROCYANURET OF COPPER, (Prussian Brown.)

This pigment is readily obtained by adding to a solution of sulphate of copper, a solution of the ferrocyanuret of potassium: a mass of a deep brown colour is thrown down; this must be frequently washed with warm water, and left to dry spontaneously. This pigment affords a rich brown colour, approaching in tint to the madder brown; at the present time it is scarcely known to artists, and the few that are acquainted with it are prejudiced against the use of it, by the gratuitous supposition of its being a very fugitive colour. From the extreme beauty of it, I was induced to submit it to several rigid trials, and from the result of my experiments, I do not consider it by any means a fugitive colour, being in that respect far superior to many that are now in daily use; at the same time, if carelessly prepared, it becomes much impaired in its durability.

I have lately manufactured a considerable quantity of this pigment, which is now extensively employed by many of the first artists, and I have reason to hope with perfect success.

COPPER AND CHLORINE,

Combine in two proportions, forming the dichloride and chloride, the atomic composition of which is as under:—

	Copper	Chlorine	At. Wt.
Dichloride ..	2 atoms 64	+ 1 atom 36	= 100
Chloride	1 atom 32	+ 1 atom 36	= 68

These two compounds are but of little importance in the arts: the dichloride, when in combination with water, forms the hydrated dichloride, or, as it is sometimes called, submuriate of copper.

BRUNSWICK GREEN.

The two following processes afford two green pigments, which are commonly called Brunswick greens, although they bear no relation to each other chemically.

Into any convenient vessel pour a saturated solution of muriate of ammonia, (sal ammoniac) to which add shreds or filings of metallic copper; cork the vessel securely, and place it in a warm apartment for three or four weeks, during which time a portion of the copper will be converted into a green powder; this when separated from the unoxidized copper, washed and dried, affords one of the best greens of this class.

The other process is simply that of adding to a solution of sulphate of copper, bitartrate of potass, (cream of tartar) stirring the mixture after each addition, until the original blue colour of the solution is destroyed, when the precipitate has settled. This, when treated in the usual manner, is an inferior pigment of the above class.

ARSENITE OF COPPER, (Emerald Green.)—See Arsenic.

DI-ACETATE OF COPPER, (Verdigris.)

The acetic acid, (vinegar) and the protoxide of copper combine in several proportions; the only one demanding attention is the above compound, forming the common verdigris of commerce, which is distinguished by the terms French and English, the former of which was for many years considered to be superior to the latter. The present method of preparing verdigris, in this country, is by forming alternate layers of copper plates, and woollen cloth steeped in acetic acid (the pyroligneous is generally employed); after a short time, the plates become corroded by the action of the acid, this is removed and the process repeated, until the plates are dissolved. The French process differs from the preceding by the employment of the stalks and husks of the grapes after the juice has been expressed, these being moistened with water or thin wine, and kept in a warm temperature, acetous fermentation soon commences; when this has taken place, alternate layers of this fermenting

mass and plates of copper are formed, which are afterwards treated in a manner similar to that described above. The verdigris of commerce is frequently adulterated with common chalk coloured blue by sulphate of copper. As a pigment it is but little employed at the present day by artists, as but little dependance can be placed upon it.

In addition to the green pigments already described, there are several native earths of a green colour, to which the oxide of copper is said to communicate the colouring matter; they are, however, of but little importance.

CHROMATE OF COPPER.

By adding a solution of Chromate of Potass to a solution of sulphate of copper, a brown precipitate is thrown down; this when treated in the usual manner, affords a pigment of a fine warm tint, between Indian yellow and Mr. Field's platina, No. 2. It has not been much used by artists.

On reference to page 14, *Exp. 4*, it will be seen that iron decomposes the compounds of copper, a fact which would at once point out the impropriety of employing a steel, or iron pallet-knife, in mixing or grinding those pigments having copper as a base.

COBALT.

The distinct character of this metal was discovered by Brandt, in 1733. Its oxides had been in use for communicating a blue tint to glass and vitreous substances since the beginning of the 16th century.

Cobalt is of a grey colour inclining to red, is very brittle, and possesses but little splendour. There are several ores of this metal, nearly all of which contain arsenic. A considerable quantity of that brought into England is in the form of a coarse grey powder, passing under the name of zaffre, being a compound of the oxide of cobalt and the metals usually associated with it in its native state, together with a much larger proportion of flint. As a metal, cobalt has not been applied to any useful purpose, its

specific gravity, when pure, is stated to be 7.7: its atomic weight is 30.

COBALT AND OXYGEN.

There are two oxides of cobalt, forming the proto, and peroxide, viz:—

	Cobalt	Oxygen	At. wt.
Protoxide..	1 atom 30	+ 1 atom 8	= 38
Peroxide ..	1 atom 30	+ 1½ atom 12	= 42

The protoxide of cobalt is obtained by decomposing the nitrate of cobalt with potass; when newly made, it is of a blue colour, but by exposure to the atmosphere changes into a dingy green.

Peroxide of cobalt is obtained, with some difficulty, by decomposing a solution of the chloride, by the chloride of calcium: it is of a black colour.

The protoxide of cobalt combines with the acids, forming a class of salts, few of which are of any great importance; the acetate and muriate have lately been much employed as sympathetic inks, in the painting of those amusing toys called magic pictures. The following process is the mode generally employed to obtain these compounds:—

CHLORIDE, OR MURIATE OF COBALT, (Blue Sympathetic Ink.)

Dissolve the pure metal, or its protoxide, in dilute hydrochloric (muriatic) acid until it is saturated; the solution, when filtered and diluted with water, which should then be of a rose colour, if placed upon paper, hardly appears visible, but by slightly warming the paper, it becomes of a beautiful blue colour, which again disappears as the paper cools.

ACETATE OF COBALT, (Green Ink,)

Would, if pure, furnish also a blue colour, when treated as directed in the preceding article. This latter preparation is generally prepared from the impure oxide (zaffre,) by boiling it in strong acetic acid, this affords

of a green colour, in consequence of its containing iron, arsenic, and nickle.

COBALTS, SMALTS, &c.

The various compounds passing under the above name, differ from each other only as regards the quantity and purity of the materials employed, depending for their colour on the property which the oxide of cobalt possesses, of communicating a blue colour to the mass when fused with vitreous substances, the intensity of the colour depending, of course, upon the quantity of oxide employed. The following process affords a very fine specimen:—Dissolve the cobalt of commerce in nitro-muriatic acid, precipitate the oxide by a solution of pure potass, throw the mass upon a filter, wash it well with warm water, and dry it; to one part of this oxide, add three of powdered quartz or rock crystal, and one of potass; place the mixture in a porcelain crucible, and submit it to an intense heat, which must be continued for some hours; the mass when cold, will present, if due heat has been applied, a deep blue glass; this, when pulverized and washed with dilute muriatic acid and dried, forms the smalts of the artists.

A blue colour of extreme delicacy may also be obtained by pouring a solution of the nitro-muriate of cobalt upon pure alumina, throwing the whole upon a filter, to allow the remaining fluid to drain from it; this, when dried, and afterwards submitted to an intense heat, affords the pigment: in tint it bears a close resemblance to the ultramarine ashes.

Considerable apprehensions are entertained of the durability of the compounds of cobalt as pigments, and these fears are not groundless, as several known cases exist of their changeable character. At the same time I have every reason to believe, that when proper care is taken in the preparation of them, they are far from fugitive, being of opinion that, where they have failed, the fault may be in a great measure attributed to one or other of the following causes:—

1st. Excess of alkali. This fault is of no unfrequent occurrence, as an excess of potass greatly facilitates the fusion of the mass, but at the same time tends to deteriorate the whole.

2dly. The impurity of the oxide, which, as before remarked, is always associated with iron, arsenic, and nickel, &c.; it must be evident, therefore, if the oxide employed contains either of these in any appreciable quantity, but a very inferior pigment can be obtained.

It has been suggested, that as the pigments of this class are the result of vitrefaction, if all the pigments employed by the artist were prepared in a similar manner, they would be better able to withstand the attacks of those bodies opposed to them; such however appears by experience not to be the case, for the degree of fineness to which they must be reduced, to render them available to the artist, subjects them to precisely the same chemical effects as if such precaution was not taken.

ARSENIC.

This metal is obtained generally from the roasting of other ores, during which process it is volatilized and conducted through long flues, in which it is condensed, forming the white arsenic of commerce.

Metallic arsenic is a brittle metal of a steel grey colour, and crystalline texture; it sublimes readily at a temperature of 360; its specific gravity is 5.8, and atomic weight 38.

Native arsenic is occasionally found in several parts of Europe, but seldom in any quantity; the metal in itself is, however, but of little importance in the arts.

ARSENIC AND OXYGEN

Afford two compounds of an acid nature, forming with salifiable bases definite chemical compounds. The quantities of oxygen and base may be thus stated.

Arsenic	Oxygen
1 atom 38	+ 1½ atom 12 = 50
1 ditto 38	+ 2½ ditto 20 = 58

ARSENIOUS ACID (White Arsenic.)

This compound of arsenic and oxygen is, as before stated, the result of certain processes, connected with the smelting of other ores, particularly those containing cobalt: a considerable quantity of which is annually obtained from the works at Joachimsthal, in Bohemia. The white arsenic of commerce is generally in the form of white semi-transparent masses, having a glossy or vitrified appearance. It is a violent poison, and therefore extreme caution is requisite in its employment. It is occasionally found native, but not in sufficient quantity to supply the demand.

Arsenious acid combines with the salifiable bases, forming a class of salts, denominated arsenites.

ARSENIC ACID

Is obtained by distilling the following mixture:— 8 parts of arsenious acid, 4 of hydrochloric, and 24 of nitric; when all the fluid contents have passed over, the bottom of the retort must be gradually raised to a dull red heat; the mass remaining after cooling is the arsenic acid. It is but of little importance in the arts.

ARSENIC AND SULPHUR.

There are three compounds of sulphur and arsenic, containing the following proportions of sulphur and base.

	Arsenic		Sulphur	
Protosulphuret	..1 atom 38	+	1 atom 16	= 54
Sesquisulphuret	1 ditto 38	+	1½ ditto 24	= 62
Persulphuret	1 ditto 38	+	2½ ditto 40	= 78

PROTOSULPHURET OF ARSENIC (Realgar)

Is sometimes found native, but the principal of that employed in this country is artificially prepared. It may be obtained in the small way, by heating in a crucible one part of white arsenic with half of its weight of sulphur: a fused mass of an orange red colour is obtained.

By the Chinese this compound is formed into vases and figures of different shapes, for medicinal purposes, in which they place some vegetable acid; this dissolving, a portion of

it, after remaining a certain time, is administered in various diseases. Realgar as a pigment is now but seldom employed, although it is said to have been freely used by the old masters; it is not a very permanent pigment, and its poisonous nature presents a formidable barrier to its free use.

SESQUISULPHURET OF ARSENIC (Orpiment.)

This is also a natural and artificial production, and is found in masses in Hungary, China, Arabia, and South America; it was by the ancients denominated auripigmentum from its bright golden yellow colour; and may be obtained artificially by fusing realgar with sulphur; it however, varies much in colour, and as a pigment for the artist, it is decidedly bad.

KING'S YELLOW.

The basis of this pigment is the orpiment above mentioned, hence that also, must be considered a fugitive body.

CHINESE YELLOW,

Is considered to be the Auripigmentum of the ancients, although, chemically speaking, it is identical with the two preceding; yet, from it being a natural production, it is not so liable to change, if it be not mixed with other pigments.

PERSULPHURET OF ARSENIC

Bears a close resemblance to orpiment in colour; it is not employed in the arts.

ARSENITE OF POTASS.

This compound is readily formed by boiling together a solution of carbonate of potass and the arsenious acid in powder; in filtering, the arsenite of potass remains dissolved in the liquid.

ARSENITE OF COPPER (Emerald or Scheele's Green.)

This is a brilliant green pigment, consisting of the protoxide of copper and arsenious acid; there are several processes for obtaining it, of which perhaps the following is one of the best:—

Mix together a warm solution of arsenite of potass and sulphate of copper, until they cease to throw down a green

precipitate ; this must be thrown on a filter, and copiously washed with boiling water ; should the colour not be very fine, the addition of a little acetic acid, boiled with the whole previous to filtration, I find greatly to improve it in brilliancy. As a pigment, I do not consider it to be very permanent, at the same time it is superior to many of the copper greens, if used unmixed with any other colour.

TIN.

This metal is obtained in great abundance from the mines of Cornwall : when pure it is of a silvery grey colour, approaching nearer in resemblance to silver than any other metal ; it is very malleable, but is not possessed of much ductility. It melts at 442° , at which point it rapidly combines with oxygen, forming a white oxide. The specific gravity of pure tin is about 7.28. Its atomic weight is estimated at 58.

TIN AND OXYGEN.

There are three compounds of tin and oxygen, forming the

	Tin.	Oxygen	At. wt.
Protoxide....	1 atom 58	+ 1 atom 8	= 66
Sesquioxide ..	1 ditto 58	+ $1\frac{1}{2}$ ditto 12	= 70
Peroxide or ..	} 1 ditto 58	+ 2 ditto 16	= 74
Stannic acid..			

The protoxide is obtained when a solution of the protochloride of tin is decomposed by ammonia ; it is of a grey colour. The sesquioxide is obtained by adding to a saturated solution of the peroxide of tin in hydrochloric (muriatic) acid the moist hydrated peroxide of iron, by which the sesquioxide of tin is formed.

Peroxide of Tin, Tin Putty, is readily formed by pouring strong nitric acid upon small fragments of metallic tin : the metal is converted into a yellow powder, this, when washed and dried at a dull red heat, forms the peroxide, which is employed by enamellers, to form their white enamel.

CHLORINE AND TIN.

There are two compounds of tin and chlorine forming the protochloride and perchloride as

	Tin.	Chlorine.	At. wt.
Protochloride..	1 atom 58	+ 1 atom 36	= 94
Perchloride ..	1 ditto 58	+ 2 ditto 72	= 130

PROTOCHLORIDE OF TIN.

This is an important combination, from the insoluble compounds which it forms with many of the vegetable and other coloured infusions: it therefore is extensively used in dying and calico printing.—(See Cochineal, Madder, and Gold.) Protochloride of tin may be formed by boiling one part of tin with two of hydrochloric (Muriatic) acid. An acid solution is obtained, which should be closely preserved from the action of the atmosphere.

An oxide of tin is occasionally employed as a white pigment, but with very little success, with the exception of the compounds formed by the action of the protochloride: this metal does not furnish any other pigment.

BISMUTH

Is a white brittle metal, having when viewed in contrast with other white metals, a faint coppery red colour. It fuses at 476°, and when permitted slowly to cool, forms very beautiful metallic crystals; its specific gravity is 9.8. and the atomic weight is estimated at 72.

BISMUTH AND OXYGEN.

There are two oxides of bismuth, the protoxide and peroxide, the former having a yellow and the latter a brown colour: they are of little importance.

SUBNITRATE OF BISMUTH, (Pearl White,)

Is readily obtained by dissolving the metal in a mixture of two parts of nitric acid (aqua fortis) and one of water; when the solution is effected, it must be filtered and the clear solution of nitrate of bismuth, thrown into a large quantity of distilled water. Decomposition takes place, and the subnitrate

of bismuth is precipitated, which, when washed and dried, is frequently employed as a white pigment.

As a pigment it is decidedly bad, the metal of commerce frequently contains minute portions of silver, these being mixed with the white are readily acted upon by exposure to light. The action of sulphuretted hydrogen is also very powerful upon it.

ANTIMONY

Is, when pure, of a white colour, with a faint tinge of bluish-grey. It fuses at 810° , and, like Bismuth, crystallizes on cooling. The common antimony of commerce is the sulphuret, which is generally in long pieces of a bluish-white colour, in the form of shining needles. The pure metal has a specific gravity of 6.7. and the atomic weight is 65.

ANTIMONY AND OXYGEN.

There are three compounds of antimony and oxygen, forming an oxide and two acids; viz.

	Antimony.	Oxygen.	At. wt.
Protoxide	1 atom 65	+ $1\frac{1}{2}$ atom 12	= 77
Dentoxide, or Antimoni-	} 1 ditto 65	+ 2 ditto 16	= 81
ous Acid			
Peroxide or Antimonic	} 1 ditto 65	+ $2\frac{1}{2}$ ditto 20	= 85
ditto			

of these combinations, the protoxide is the only one which combines with the acids to form the various salts of antimony, hence it is called the only salifiable base.

Hydrosulphuretted oxide of antimony: (Kermes Golden sulphur of Antimony.)

Kermes mineral, and the golden sulphur of antimony are occasionally employed by the artist, but less so than formerly, being by no means eligible pigments. The following process affords them in great purity.

Equal parts of the common powdered sulphuret of antimony and common potass are fused together in a crucible, the mass when cold must be finely pulverised, and boiled in ten

times its weight of distilled water, and filtered while hot; as it cools, it deposits the kermes. When the latter ceases to fall down, the clear liquor must be decanted off, and the addition to it of dilute sulphuric acid will precipitate the golden sulphur of antimony.

NAPLES YELLOW.

This pigment is a variable compound of the oxides of lead, antimony, and earthy matter; it is prepared in various ways, and differs much in colour, depending upon the quantity of oxide either of lead or antimony. The following process affords the pigment in tolerable purity.

Take 12 oz. of the carbonate of lead (ceruse),
2 oz. of common sulphuret of antimony,
 $\frac{1}{2}$ oz. of calcined alum,
1 oz. of muriate of ammonia (sal ammoniac.)

These ingredients must be finely pulverised, and placed in a crucible with another inverted over it. Apply at first but a gentle heat, which must be gradually elevated until the crucible and contents are brought to a dull red heat; the whole may then be removed from the fire, the mass when cold must be reduced to powder, and repeatedly washed with warm water and dried; care should be taken not to employ any iron instrument during the process, as that metal would decompose the pigment, and consequently deteriorate the colour.

ZINC.

This metal, although extensively employed by the ancients in the manufacture of their brass, is generally supposed to have been employed in the rough ore, and that in its metallic state it was unknown to them. Pure zinc is a bluish-white metal, presenting when fractured a crystalline arrangement: at common temperatures it possesses but little ductility or malleability, but when heated to a temperature a little above that of boiling water, it admits of being rolled out into tolerably thin plates, and of being drawn into wire; the

specific gravity of pure cast zinc is about 6.8. Its atomic weight is stated to be 82.

ZINC AND OXYGEN

Are considered to form but one definite compound, which is readily obtained when the fused metal is exposed to an intense heat. The metal takes fire and burns with a pale blue flame, oxygen is absorbed, and an oxide formed, which if not confined, owing to its levity, continues to rise from the crucible in the form of a white flocculent substance, bearing some little resemblance to wool, hence it was formerly called philosophers' wool. This oxide is extensively prepared in the large way, but is seldom very pure; it passes under the name of tutty powder.

It is occasionally employed as a white pigment, but I have reason to believe with little success, being much inferior both in body and colour to the whites with a base of lead, and but little, if any, superior to them in durability. The Chinese white spoken so highly of by some artists is, I have reason to believe, manufactured from this oxide.

Zinc does not furnish any pigment of value to the artist; with the chromate of potass, a yellow chromate of zinc is precipitated, but far inferior to the chromate of lead.

SCARCE METALS.

Of the following metals many of them are obtained only in very limited quantities, and several of them at so high a price, as to preclude their ever being applied to the arts. We shall, therefore, briefly notice their general properties only.

Palladium, osmium, iridium and rhodium. These metals are all obtained from the crude ore of platinum. Palladium was discovered by Dr. Wollaston in 1803, it is a metal of a dull white colour, and is both ductile and malleable. Pure palladium has a specific gravity of 11.3. Its atomic weight is 54. There are two oxides, the one forming a black protoxide, and the other a brown binoxide.

Rhodium was discovered by the same eminent chemist,

and much about the same time as the preceding; it is a white metal, having a specific gravity of 11. Its atomic weight is stated to be 52. When pure, it is not acted upon by any of the acids; from its extreme hardness it has been successfully employed in forming the nibs to metallic pens, by which their durability is greatly increased.

Osmium—this metal was discovered by Mr. Tennant in 1803, it is obtained in the metallic state with considerable difficulty, and is said to form with oxygen five definite compounds.

IRIDIUM

Was discovered by the same chemist in conjunction with osmium; it is of a white colour, but little is at present known of its general properties.

VANADIUM.

This metal derived its name from a Scandinavian Deity called Vanadis, it was discovered in 1830 by Sefström, in the ores of iron and in the slags of the reducing furnaces in Tabery of Sweden; it has since been discovered in some specimens of lead ore. It is a brittle metal of a lustre resembling silver, its atomic weight is 68. With oxygen it forms two oxides, and an acid, called vanadic acid.

CADMIUM.

This metal occurs in the ores of zinc, and was discovered by Professor Stromeyer in 1817; it resembles tin in many of its properties, its specific gravity is 8.6., and the atomic weight is 56. Its oxide is of an orange colour, and would no doubt form a good pigment did there exist a sufficient supply of the metal.

MOLYBDENUM.

The compounds of this metal were known for some years prior to the discovery of its metallic base, which was made known by Hielm in 1782: it exists naturally in the state of a sulphuret. The metal, which is exceedingly difficult to fuse, is of a whitish-gray colour, forming with oxygen two oxides, and molybdic acid. Its atomic weight is 48.

CERIUM

Was discovered in 1803, by Hisinger and Berzelius, and is described as being a white brittle metal, forming with oxygen two oxides and a subperoxide. It is obtained from a mineral called Cerite and also in Gadolinite; the name Cerium is derived from the planet Ceres. Atomic weight 48.

TUNGSTEN

Is a metal of an iron gray colour, and very difficult to fuse: it was discovered by Messrs. de Luyart; with oxygen it forms an oxide, and an acid, called tungstic acid. The atomic weight of the metal is stated to be 100.

TELLURIUM

Was discovered by Müller in 1782, and was named by Kalproth, Tellurium, from Tellus the earth. This metal differs from many of the preceding in not being difficult of fusion, it is of a bright gray colour, forming with oxygen two oxides; its atomic weight is 32.

URANIUM.

From its being discovered in the same year that Herschel discovered the planet Uranus, was by its discoverer Kalproth named after it. It is very difficult of fusion, possessing a grayish-brown colour, the atomic weight is estimated at 217. With oxygen it forms two oxides.

TITANIUM

Was discovered by Mr. Gregor, but received its name from Kalproth, after the Titans of ancient mythology; it is generally obtained in the form of a dark blue powder. With oxygen it forms an oxide, and Titanic acid. Its atomic weight is 24.

COLUMBIUM

Was discovered by Mr. Hatchett in analyzing a mineral from the cabinet of the British Museum, and was afterwards obtained by M. Ekeberg; it is said to resemble iron in colour, it unites with oxygen, forming an oxide, and an acid called Columbic acid. Its atomic weight is 185.

NICKEL.

This metal, although more abundant than those above enumerated, is yet but little employed in the arts, with the exception of an alloy composed of copper, nickel, and zinc, forming the German silver.

Nickel is a white brilliant metal, possessing very feeble magnetic properties; this fact is denied by some, from the difficulty with which it is separated from iron, being generally more or less associated with it. Its specific gravity is 8.5. and atomic weight 28. With oxygen it forms two oxides.

SILVER

Occurs in combination with sulphur, forming the sulphuret; it is also occasionally found combined with ores of lead, in many of which it is in sufficient quantity to pay the smelter for its separation; it is also found native, but seldom absolutely pure.

Pure silver is both malleable and ductile, melts at a bright red heat, and if intensely heated, evaporates. The specific gravity of pure silver is 10.5., and its atomic weight 108.

SILVER AND OXYGEN

Form but one combination, which consists of

Silver.	Oxygen.	At. wt.
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Oxide of Silver..	1 atom 108	+ 1 atom 8	= 116.
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The oxide of silver combines with the acids, forming a class of salts, which are rapidly acted upon when exposed to the direct rays of the sun, or more slowly by daylight;

NITRATE OF SILVER.

Nitric acid acts rapidly upon metallic silver, first oxidizing it, and then forming with it a clear solution of nitrate of silver; this when evaporated to dryness, and afterwards fused, forms the lunar caustic. A solution of nitrate of silver when exposed to the day-light, is very speedily decomposed, the silver being precipitated in the form of a black powder.

INDELIBLE MARKING INK

Is simply a solution of the above salt, the cloth intended to receive the ink being first wetted with a solution of carbonate of soda, holding gum in solution forming a mordant: by exposure to the light, the silver is precipitated on the lines traced by the pen; on account of this property it forms the principal ingredient in hair dyes.

Oxide of silver furnishes, with several compounds, very beautiful pigments, but they all possess the above property of changing colour by exposure to light; hence to the artist they are of course of no service.

GOLD,

Like silver, is occasionally found in the metallic state, but seldom very pure, being alloyed with other metals; the specific gravity of pure gold is 19.3. It melts at a bright red heat, and possesses the properties of malleability and ductility in an eminent degree. The atomic weight of gold is estimated at 200.

GOLD AND OXYGEN.

There are two oxides of gold as under:

	Gold.	Oxygen.	At.wt.
Protoxide	1 atom 200	+ 1 atom 8	= 208
Peroxide	1 ditto 200	+ 3 ditto 24	= 224

The protoxide is formed by dissolving gold in nitromuriatic acid (composed of one part by weight of nitric and two of hydrochloric acid), the result of which is a protochloride of gold. If to this a solution of pure potass be added, a protoxide of gold is precipitated.

PEROXIDE OF GOLD

Is obtained with some difficulty, it is of a black colour, and from its action upon the alkalies, is supposed to act as an acid, and has therefore been called auric acid; it is speedily reduced to the metallic state by exposure either to heat or light.

GOLD POWDER.

This substance, although but little employed in the present day, was formerly much in repute, more particularly in those paintings intended to embellish the missals of the Romish church.

It is prepared in various ways, either by grinding gold leaf with honey, and afterwards washing out the latter, or by precipitating a solution of gold by sulphate of iron.

The following process I consider the most eligible—dissolve pure gold in nitro-muriatic acid to saturation, and filter: to the clear solution add half as much sulphuric ether, and agitate the mixture, the chloride of gold will be taken up by the latter, which from its specific gravity will float upon the acid; it must then be carefully decanted and evaporated to dryness, which leaves the gold in a minute state of division.

OXIDES OF GOLD AND TIN, (Stannate of Gold, Purple Powder of Cassius.)

This pigment is now only employed by the enameller, the Ultra-marine and Cobalt having nearly superseded it. It is readily obtained by adding to a saturated solution of gold, a saturated solution of tin, the purple powder is precipitated, which requires to be well washed and dried out of contact of the light.

PLATINUM

Was discovered by Mr. Charles Wood, in the year 1741. It is usually found in the metallic state in the form of small grains, or scaly particles, and is principally obtained from South America, Brazil, Peru, and the Uralian Mountains of Siberia.

The pure metal is obtained in masses with some difficulty, owing to its infusibility. The intense heat given out by the oxy-hydrogen blow pipe is, however, fully adequate to effect its fusion, and may be successfully employed upon masses not exceeding half a pound in weight; not that it can retain that quantity in fusion at one time, but, by adding

small pieces, it aggluternises them sufficiently, to enable them to be worked into plate or drawn into wire.

Pure platina is of a silvery white colour, extremely ductile, but its malleability is inferior to that possessed by gold, and like the latter metal, it is only acted upon by nitromuriatic acid. The specific gravity of fused platinum is 21.16, being the heaviest element in the whole class; its atomic weight is estimated at 96.

PLATINUM AND OXYGEN

Form three compounds, but like gold, the affinity between the two elements is very feeble, from which circumstance, they are readily decomposed by bodies which affect the oxides but slowly.

	Platinum.	Oxygen.	At. wt.
Protoxide	..1 atom 96	+ 1 atom 8	= 104
Sesquioxide	..1 ditto 96	+ 1½ ditto 12	= 108
Peroxide	1 ditto 96	+ 2 ditto 16	= 112

Protoxide of Platinum is of a black colour, and may be obtained by acting upon the protochloride with a solution of caustic potass.

The sesquioxide is a gray powder, and may be obtained by heating in a crucible, spongy platinum and caustic potass, the mass when cold, is to be washed first with dilute nitric acid, and afterwards with water.

The hydrated peroxide is, when carefully prepared, of a deep brown colour, appearing in the mass almost black; it may be obtained by gently heating the perchloride in sulphuric acid, by which the former is decomposed, and the metal is left in the state of a persulphate; to the latter must be added a solution of nitrate of baryta, sulphate of baryta is precipitated, and a perntrate of platinum remains in solution, to which caustic soda is to be added, a yellow precipitate is thrown down; this, when washed and carefully dried, is the brown hydrated peroxide, which, if heated, gives out water, and is converted into the black peroxide, the latter,

if the heat is increased, is decomposed, oxygen being evolved, and the metal revived.

When solutions of the alkaline and earthy salts are added to solutions of platinum, various triple compounds are formed, generally of a yellow or buff colour, called platino-chlorides. Two of these Mr. Field has lately introduced, together with a compound which he calls dark platina, or platina No. 3, the former being distinguished by the number 1 and 2; the dark platina appears to me to be the peroxide of platina, although I have not had an opportunity of submitting it to analysis.

As pigments, I am rather fearful of their being permanent bodies, judging from the known characters of the compounds of the metal; in justice to Mr. Field, however, I would add that he has submitted them to those tests, which he considers sufficient to warrant him in considering them, by no means, ineligible pigments: their price will however exclude their free use.

LEMON YELLOW.

This compound as now prepared has been noticed under the article Barium: when first introduced by Mr. Field, it was prepared from the above metal; its price acting as a barrier to its general use, has, I presume, induced him to work upon different materials; this however, is not generally known, many artists considering it still to be a compound of the metal platinum. The lemon yellow I tested was a chromate of baryta, and as a pigment I consider it far superior in durability to any compound of the above metal; I find however, that the sun's rays, deprives it almost entirely of the delicate yellow, which gives it its peculiar value, reducing it almost to a level with the baryta white.

VEGETABLE CHEMISTRY.

IN the preceding sections we have briefly examined the elementary substances, constituting in one sense the inorganic part of the globe. Those hereafter to be examined, although made up of one or more of these bodies, are yet distinct from them, constituting what is commonly termed organic chemistry, or that portion which relates to the chemical composition of bodies possessing, at one time or other life and motion; with the property of performing certain functions peculiar to each species.

The only essential elements apparently necessary to the growth and structure of the immense varieties of the vegetable kingdom, together with all their products, seem to be oxygen, hydrogen, carbon, and in some few cases nitrogen. In an elementary work of this nature, it would be impossible to enter into the various functions of organized life; we must, therefore, confine ourselves briefly to the examination of those products, resulting from the due exercise of these functions.

VEGETABLES.

The leaves of plants are said to be the lungs of the vegetable, by which they are enabled to appropriate to themselves, by absorption or otherwise, the necessary elements peculiar to each; during the day time, plants are known to absorb carbon, from the carbonic acid present in the atmosphere, and at the same time to give out oxygen. During the night, or in the dark, this absorption is reversed, plants then give out carbonic acid gas, hence the injurious effect of growing plants in a sleeping-room. These properties are taken up by the sap, and mixing with that portion derived by the roots from the earth, these undergo certain changes, peculiar to the vegetable, the products of which are a variety

of compounds, which have received the name of proximate principles. Of which the following are the most important :

Gum
Sugar
Starch
Gluten
Extractive Matter
Lignin
Tannin
Colouring Matter
Wax
Fixed Oil
Camphor
Resins
Vegetable Acids and Alkalies.

GUM.

As a specimen of true gum, that commonly called Arabic may be taken ; it is derived from the sap, and is often in so large a quantity, as to exude spontaneously from the tree. It is tasteless and inodorous, of a slight yellow colour, and frequently transparent. It unites with water, forming a thick mucilage, but will not dissolve in alcohol.

The gum arabic is the produce of the Egyptian Acacia ; it flows, or rather exudes, in a thick viscid state, which by evaporation gradually becomes hard without losing its transparency,

When gum, by a peculiar process is resolved into the simple elements composing it, it is found to be a compound of

Gay-Lussac

Oxygen	50.84
Hydrogen	6.93
Carbon	42.23

In 100 parts.

When gum is acted upon by nitric acid (*aqua fortis*), a peculiar acid is obtained, called *mucic acid*.

The cherry tree and tragacanth afford varieties of this substance, as also the *sarcocolla*, of Ethiopia.

Gum, when used in large quantities by the artist, should always be mixed with some viscid substance, as honey or loaf sugar, to prevent it contracting as it becomes dry, and peeling from the surface of the paper.

SUGAR.

This substance is principally obtained from the sugar cane, but all ripe vegetables, and those of a sweet taste contain it; honey and manna are but varieties of sugar. In all rough sugars there is one portion that can be made to crystallize, as the white sugar candy, and the other as treacle or molasses that will not. The process of refining sugar consists merely in the separation of these two bodies.

The sap of many other vegetables contain this saccharine principle, as the beet root, the maple, carrots, parsnips, &c. &c.

It may be obtained from milk, hence called sugar of milk; and also from the urine, during the continuance of a peculiar disease called *diabetes mellitus*.

Sugar by analysis affords in 100 parts

Carbon	42.47
Oxygen	50.63
Hydrogen	6.90

100.

Sugar may also be obtained by an artificial process, as will be shown in the next article.

Nitric acid converts sugar into oxalic acid (which see), and the sulphuric acid immediately decomposes it, precipitating the carbon.

STARCH.

The best arrow root will afford an example of pure

starch, or, as it is sometimes called, *Fecula*. It is principally obtained from the esculent grains and roots.

To obtain starch from wheat, the grain is soaked in water until it becomes soft and pulpy, it is then placed in coarse linen bags and submitted to pressure; a milky fluid is pressed out which finally deposits the starch, the clear liquid is then drawn off, and the starch dried in a moderate heat; before becoming quite dry it contracts and splits into the shape in which it is met with in the shops. The starch however, prepared for the laundress, is more frequently obtained from potatoes, by a process somewhat similar, and previous to drying is coloured faintly blue by smalt.

Pure starch is a white powder, insoluble in alcohol and cold water, but readily dissolved by water at a temperature of 168°; the heat should not exceed this, or the starch will form a coagulum. A solution of starch is always glutinous, and forms a beautiful test for free iodine, consequently the latter substance is also a test for starch: they unite together, forming a deep blue compound. It was formerly imagined, that this might be made serviceable to the dyer, but when the solution thus formed is boiled for a few minutes, the colour is immediately discharged by the volatilization of the iodine.

Pure starch by analysis is found to consist of in 100 parts,

Carbon	48.55
Oxygen	49.68
Hydrogen	6.77

. 100.

On referring to the properties of the elements entering into the composition of this and the preceding compound, it appears singular that so small a difference in quantity should present two bodies of so opposite a character; and further, that if by any means we could reduce the quantity of carbon in the latter, we ought then to have a compound similar in its properties to sugar. Now this process is

always effected when barley is converted into malt; a portion of the starch of the barley is changed into sugar, when the former has undergone the process of malting.

Sugar may also be obtained by acting upon starch, by dilute sulphuric acid; this singular fact was discovered by M. Kirchoff.

Nitric acid, assisted by heat, converts starch into oxalic acid.

Sago, tapioca, cassava and salop are all varieties of starch.

GLUTEN,

May be obtained from wheat flour; if a portion of flour is formed into a paste with water, and well kneaded in a large tub full of the same liquid, the paste will be found to have deposited a white pulverent matter, which is starch; the remaining substance is an elastic insoluble body, which is the gluten; it is of a gray colour, and is said to resemble newly solidified caoutchouc, except that no change in colour takes place by exposure to the air. It is elastic, and may be drawn out like the former, shrinking back again to its former dimensions. If dried slowly and at a moderate heat, it is converted into a hard horny substance, somewhat resembling glue; if however, it is left exposed in its moist state, it soon passes into the putrefactive fermentation.

This substance contributes greatly to the nutritive quality of the wheat flour; from an estimate made it appears that the wheat of this country contains from 18 to 24 per cent. of gluten. During the process of bread making, the carbonic acid generated, is in some measure retained by the gluten; this puffs and swells the latter, by the aid of heat, its elasticity is in part destroyed while thus distended, constituting the spongy character of new bread.

Some chemists deny that gluten thus obtained is a proximate principle, but a compound consisting of two others, which they have named Gliadine and Zimoma; this view is again opposed by the other party who consider the pasty mass to

be a compound of true gluten, and a substance called vegetable albumen.

Powdered gum guaiacum has been proposed as a test for gluten, with which it forms a fine blue colour.

CAOUTCHOUC, OR INDIAN RUBBER

Has been proved by Mr. Faraday to consist entirely of carbon and hydrogen. It is chiefly obtained from the *Hevæa caoutchouc* and *Iatropa elastica*, trees growing in Brazil; when first drawn from the tree, it has somewhat of the appearance of cream, and smells like sour milk: by exposure to the air it is separated into two substances, one of which (the true caoutchouc) is deposited, the other is a liquid which does not solidify. The former by degrees changes to a black colour. It is insoluble in water; at the same time, by long boiling in that fluid, it is converted into a viscid mass resembling bird lime. The volatile oils, as oil of turpentine, cajeput, and also naphtha and coal tar, dissolve it. I have noticed a singular circumstance attending the solution of caoutchouc in spirits or oil of turpentine, which I do not remember to have seen noticed before. Some two years back, I undertook some experiments with a view to the adoption of a solution of this substance, as a vehicle for artists, in which I did not succeed, from the circumstance of its remaining in a viscid state some weeks after it had been applied to the canvass; with the exception of this inconvenience, it answered very well. I have a slight sketch painted with it, which stands remarkably well, and is now quite dry and firm; the solution when first obtained, was of the consistency of weak size, but rather darker in colour; not having succeeded in my expectations, the bottle containing it, about a quart in quantity, was placed on a shelf in the laboratory, and forgotten. I should mention also, that there was a considerable portion of solid caoutchouc in the solution unacted upon. On examining the same some few weeks back, I was surprised to find it as clear and transparent as the original turpentine employed, and at the bottom of the vessel

a deposition of a lightish brown colour, seeming to be the colouring matter of the caoutchouc. The solution now instead of being of the consistence of size, is as thin as water; from which it would appear, that the colouring matter of caoutchouc is a different substance, and (unlike the former) insoluble in turpentine. The solution before this could not be made to pass the filter, now it flows through as freely as water.

A company has lately been formed for rendering this substance available in a variety of useful and important ways, at the head of which stand two eminent artists; therefore should it be found of any service to the fine arts, these gentlemen will not, I am sure, neglect its application.

EXTRACT.

The pigment sap green, may perhaps suffice for an example of an extract. At the same time, the latter is no longer distinguished as a distinct principle, for it is obvious, that all vegetables afford extracts, and that such extracts must consist of the soluble parts of the plants from which they were obtained.

The pigment sap green is obtained from the juice of unripe buckthorn berries; the expressed juice is strained and evaporated to dryness; it is not unfrequently mixed with alumina (which see) to give it body.

LIGNIN

Is the insoluble woody or fibrous structure of trees and vegetables, or that portion remaining after the soluble matter has been removed by digesting wood in water and alcohol.

When the wood of trees is submitted to destructive distillation, it furnishes an abundant acid liquid, formerly called pyroligneous acid. This is now found, (after it has been purified from its original unpleasant odour,) to be identical with the acid of vinegar, or acetic acid; several gases are also given out during the process, together with a substance of a tarry nature, called oil of tar. From this oil of tar M. Reichenbach obtained the medicine lately introduced

called creosote, (from two Greek words signifying to preserve flesh); from the supposition that this substance furnishes to smoked meats their antiputrescent quality. There remains in the retort after the volatile matter has been drawn over a light black brittle shining body, or charcoal, which may generally be distinguished from that obtained in the usual manner, by the appearance of being as it were studded or coated on the outside with a substance resembling silver; and I have been informed by consumers of charcoal, that it is far inferior to it.

Lignin consists of carbon, oxygen, and hydrogen.

Some very interesting experiments were made by Professor Autenrieth, with a view to ascertain the practicability of converting wood into wholesome and palatable food. The wood is so prepared as to convert it into lignin; it is then reduced to a fine powder, and frequently baked; this is again ground as fine as flour, and used in a similar manner; and like it will not ferment unless some fermenting body, as leaven, be added to it. It then forms a light spongy loaf, far superior to that obtained from the bran of wheat, which in times of scarcity is not unfrequently made use of.

TANNIN

Is that property possessed by certain vegetable bodies of converting animal jelly into leather. It may be obtained from nut galls, pomegranate bark, oak bark, grape seeds, or from a substance called catechu.

Tannin has been found to consist of

Carbon.....	50.55
Oxygen	45.00
Hydrogen	4.45

In 100.. parts.

Pure tannin is very difficult to obtain, being in most cases a mixture of other vegetable principles. When pure it

is a colourless substance, easily soluble in water, and of an astringent taste.

An artificial substance resembling tannin was discovered by Mr. Hatchet, by acting upon charcoal with dilute nitric acid, but such has not been as yet applied to any useful or economical purpose.

COLOURING MATTER.

We now arrive at the consideration of an important proximate principle, viz: the colouring matter of vegetables, forming one of extreme interest both to the artist and the dyer, and on which depends the whole of the vegetable pigments.

The variations of colour existing in the vegetable kingdom is of the most vivid description, but upon observation, the prevailing tints will be found to consist of reds, yellows, blues, and greens. The colouring matter is in most cases easy to be obtained, from some by mere infusion, but as thus extracted, it is always more or less contaminated with other soluble matters contained in the plants.

The acids and alkalies, in most cases, effect very important changes in the vegetable colours; the former changing the blues to red and the latter to greens.

Chlorine, in like manner, totally destroys the colouring matter of all vegetables. The sun's rays act in a similar manner to the bleaching property of chlorine. A slight elevation of temperature above that of boiling water is sufficient also to decompose many of them.

The preparation of most of the vegetable pigments depends on the powerful affinity possessed by several of the metallic oxides for this vegetable colouring matter. These bodies with the dyer are called mordants, and seem to act by combining with the colouring matter of the vegetable, forming insoluble compounds. The oxides principally employed for this purpose, for producing pigments, are the oxides of tin and aluminum. The lakes and madders are examples of this class.

The chemical process dependent upon the preparation of these pigments, being precisely the same, it would be useless to examine them individually: we shall therefore, describe the mode employed in the lakes and madders, and then examine the colouring matter of each.

The mode of manufacturing the lakes and madders is one of considerable difficulty, and circumstances sometimes arise during the process, which the manufacturer appears to be unable either to control or explain; so much so that the it has often been noted that the same manufacturer, operating at two different times upon the same sample of madder root, observing precisely the same quantities and mode employed in both cases, he obtains from one a fine pigment, from the other, one of a very inferior nature.

Without doubt, the first manufacturer of these pigments in England is the justly celebrated Mr. Field, of Brentford; he has succeeded in obtaining some of the most beautiful and regular compounds of this class. In manufacturing these pigments, it is not sufficient that the operator be simply a chemist; he must be also fully acquainted with various peculiarities attendant upon their manufacture, which knowledge can only be obtained by an extensive acquaintance with the processes peculiar to each. Now with the mineral pigments, it is different in one sense, for with the latter, if certain rules be followed and the compounds employed be pure and correct as to quantities, certain results must take place, these however may be greatly modified both by the skill of the manufacturer, and his attention to the process. From this it is evident, that all the books in the world would never enable a person to manufacture these pigments with success, unless practice of no mean extent be added to his knowledge acquired from them.

MADDER LAKES.

The plant from which the madder colours are obtained is the *Rubia Tinctoria*, the colouring matter of which resides

in the roots. It is a native of the Levant, Italy, Switzerland, and the more southern parts of France. It is largely cultivated by the Dutch, who principally supply the English market.

The root is perennial, having an annular stalk. It may be made to grow in any soil, but succeeds best in a rich soft one of a sandy nature: its culture has often been attempted in England, but hitherto without success.

The roots, when removed from the earth, are allowed to dry spontaneously, after which they undergo various processes of peeling, drying, and pulverising.

The colouring is supposed to consist of two substances of a distinct nature; with respect to their colouring property, one of these is of a fawn colour and the other red, the latter constituting the peculiar dye called turkey red.

In the manufacture of the madder pigments, it becomes therefore of importance to separate these two, for upon their due separation depends the purity of the pigment; this preliminary operation being performed, the following method is resorted to for the manufacture of the pigment.

An infusion of the colouring matter is obtained by long digestion and agitation in distilled water, iron vessels being avoided, experience proving, that in such the colouring matter is decomposed; the infusion is then filtered and mixed with a solution of alum or muriate of tin, this decomposed by the addition of an alkali, by which means either the oxide of alumina, (the earth alumina,) or the oxide of tin is precipitated; these at the moment of liberation immediately combine with the colouring matter present, falling down as insoluble precipitates, carrying with them in combination the colouring matter of the root; these are then washed and dried, forming the pigments, extra madder lake, madder brown, rose madder, &c. &c. according to their varieties in tint, the mode employed in the manufacture, and the quality of the root.

The colouring matter of madder seems to possess a singular

affinity for the bones of animals, as the bones of those that have been made to eat this plant and afterwards killed, have been found dyed of a beautiful red colour.

Alcohol, or pure spirits of wine, dissolves the colouring matter of madder: Pure potass forms a violet colour with madder, and the sulphuric acid a fawn colour.

ALYCARINE.

This substance has been obtained from the colouring matter of madder, by Colin and Robiquet, to which they have given the above name, from the name of madder in the Levant.

It is obtained by a complicated process, and is supposed to be the true colouring matter of the plant. It has not, that I am aware of, been applied to any useful purpose; when pure, it is in the form of brilliant yellowish red crystals, which possess in many respects the properties of an acid.

The analysis of 100 parts of madder affords the following substances.

Fatty matter of a red brown colour, resembling wax	{ 1 0
Red resinous matter	3 0
Red extractive ditto	20 0
Oxidised extractive	5 0
Brownish green	8 0
Lignous fibre	43 5
Acetate of Potass and Lime	8 0
Phosphate, Muriate and Sulphate ditto	2 0
Silica	1 5
Oxide of Iron	0 5
Waste	7 5

100 0

BRAZIL WOOD, (Lakes.)

The tree furnishing this colouring matter is supposed to be a native of Brazil, (the Brazil wood tree, or *Coesalpinia*

exists, is found in America, and many other parts of the globe.

The wood when recently cut down, is of a pale red, but becomes darker by exposure to the atmosphere. It is the ligneous structure only which furnishes the colouring matter.

Water extracts this colouring matter, but alcohol is the best solvent. If paper stained by Brazil wood be exposed to an alkaline body, it is changed to a violet, and by an acid to a yellow colour.

A lake may be obtained by a process similar to the preceding, but it is by no means so fine in colour, or so durable.

The following vegetables also afford red colouring matter, but generally of a nature too fugitive to be of any value as pigment.

Rocella, from the *Rocella tinctoria*, known in commerce under the various names of Cudbear, Archil.

Safflower, from the *Carthamus tinctorius*, a native of Egypt and the warmer climates of Asia—to obtain the colouring matter, which is of a fine rose-red colour, the dried leaves are soaked in a weak solution of carbonate of soda or potass, the colouring matter being insoluble in water; when this is effected, the carbonate is decomposed by the juice of fresh lemons, or citric acid, and the colouring matter is precipitated. When dried it forms India or China lake. When distributed in saucers and allowed to dry, it forms the pink saucers for dying, and when mixed with French chalk, the cosmetic rouge.

Litmus, called also Turnsole from the *croton tinctorium*—the colouring matter obtained from this plant, is of so fugitive a nature as to render it of no value in the arts, it however furnishes the chemist with a valuable test for acids and alkalies, under the name of litmus before described.

YELLOWS, BUFFS, AND FAWNS.

The pigments of this class are but of little value to the artist, being powerfully acted upon when exposed to the

influence of light. They are usually prepared by treating the vegetable colouring matter to combine with various earthy bodies, chalk being the one generally employed.

QUERCITRON BARK, OR THE BARK OF QUERCUS TINCTORIA.

This substance affords, it is said, one of the most permanent of this class, at the same time, it is far from being a fixed colour. It may be made, by the addition of metallic salts, to assume a great variety of tints, from Lemon Yellow to Drab and Olive. It is largely consumed by the dyer, but cannot be depended upon as a pigment.

ANNOTTO.

The tree affording this colouring matter is the *Bixa Orellana*, a native of South America. It is common also in Jamaica, and other parts of the West Indies, and in Java and Sumatra. The colouring matter is contained in the pulp of the pods. The colour, when prepared, is very little acted upon by water, the alkalies dissolve it freely. The liquor sold under the name of Scott's Nankin Dye, is said to be a solution of this description: it is far from being a permanent colour.

FRENCH BERRIES,

Or the seeds of the *Rhamnus Infectorius*, a native of Spain, and the southern parts of France; very fugitive.

TURKEY BERRIES.

The same brought from Turkey.

SAFFRON,

From the *Crocus Sativus*; very fugitive.

BLUES—INDIGO.

Indigo is the produce of *Indigofera*, the colouring matter of which exists in every part of this plant. It is grown in warm climates, nor can it be cultivated in less favorable situations. The process for obtaining the colouring matter from this plant is one requiring considerable skill and attention, without which, it seldom succeeds.

Indigo has been attentively examined by several chemists.

it is, when pure, of a deep blue colour, and contains about 50 per cent. of pure colouring matter.

Pure Indigo is but little acted upon by water, nor is it dissolved by the nitric or muriatic acids, the true solvent being the sulphuric acid, or oil of vitriol.

When Indigo is heated to between 500 and 600 degrees, about 18 to 20 per cent. of the quantity is sublimed, forming acicular crystals.

INTENSE BLUE.

Or the Saxon blue of the dyers, is made by dissolving Indigo in oil of vitriol; when the solution is complete, the mixture is diluted by adding successive portions of water, permitting the mixture to cool between each addition. The solution is then to be neutralized, by adding a solution of potash: a deep blue precipitate is thrown down, which must be further washed by a dilute solution of potash, and dried, forming the pigment Intense Blue. This substance has received the name of Cerulin, and differs from the common Indigo in being soluble in water.

Several other chemists have succeeded in obtaining compounds from Indigo, as the Phenicin of Mr. Crum, and the Indigogene of Berzelius. The action of nitric acid afforded an acid to Liebig, to which he has given the name of Carbazotic Acid. Dr. Buff obtained another acid by the action of dilute acid, to which the name Indigotic acid has been given. Pure indigo, by analysis, is found to consist of,

Carbon	73.22
Oxygen	12.60
Nitrogen	11.26
Hydrogen	2.92

100.

The blues of Indigo, are not so permanent as pigments for the artist, as they are with the dyer, probably on account of the ruinous practice of the former, by their indiscriminate mixture on the pallet. The Intense Blue is also objected to

by artists, on account of it being so rapidly absorbed by the ground or paper upon which it is laid, and the utter impossibility of laying any other tint over it, when used in water. This, however, I should in a great measure attribute to the impure nature of the pigment tried, for if the oil of vitriol is not thoroughly washed out, it is very likely to have the effect described.

WAX.

This substance is both an animal and a vegetable product. It was formerly imagined, that the bees acted the part of collectors only. But it has since been discovered, that they have the power of converting sugar or saccharine matter into wax.

It may, however, be obtained from a great variety of plants, constituting the glossy varnish of the leaves.

The analysis of 100 parts of wax, afforded Gay Lussac:

Carbon	81.784
Hydrogen	12.672
Oxygen	5.544
	100.

A substance resembling wax has been obtained from cork, by Chevreul, to which the name Cerine has been applied.

VEGETABLE OILS.

These may be divided into two classes, viz. Fixed and Volatile, the latter being easily volatilized without leaving any residue, as oil of lemons, lavender, and turpentine. The former may be again divided into two classes, viz. the fat and drying oils. The principal of the fat oils are those obtained from the almond, olive, rape seed, and castor oil. The latter, or drying oils, are those obtained from the linseed, walnut, poppy seed, and hemp seed.

We might conveniently add another class, which being generally of the consistence of soft butter, have received the name of vegetable butters. In this class we have cocoa-nut oil, palm oil, and nutmeg oil.

Fixed oils are usually obtained by expression. The seeds being submitted to the action of a powerful press, the oil exudes, leaving behind the oil cake. These oils are generally insipid, and are not capable of mixing with water without the addition of a third body, either of a mucilaginous or alkaline nature. With the former, the combination is termed an emulsion, the oil being merely mechanically suspended; with the latter, however, a chemical compound is produced called soap, to be hereafter examined.

These oils always swim or rise to the surface of water, if mixed with that fluid and allowed to settle, from the circumstance of their being bulk for bulk, specifically lighter. When the temperature of the atmosphere is such that water freezes, which takes place when the thermometer stands at 32° , these oils, the fat oils in particular, separate into two substances, one of which falls to the bottom, being insoluble, to which the name of stearine has been given; and the other, which always remains fluid, unless the cold be very severe, called elaine. When the oil is in this state, if the latter be poured off from the former, and it be dried by being pressed between folds of blotting paper, the stearine is obtained.

These oils vary considerably in the proportion of the elements contained in them; these, however, are but few, viz.

Carbon.

Hydrogen.

Oxygen.

At a temperature of 600° they are decomposed, and when made to pass through a red hot gun barrel, are resolved into carburetted hydrogen gas, carbonic acid gas, and charcoal; or, when burnt in a lamp, they furnish water and carbonic acid gas only.

The principal difference between the fat and drying oils, consists in the different effect produced by exposure to the atmosphere; the former becoming rancid, and at the same time more viscid; the latter, on the contrary, become covered

with a pellicle, and if the quantity be but small, as on the pallet, it is converted into a kind of varnish, hence their name.

The oils employed by the artist are the linseed, poppy and nut oil; the former is the one principally made use of. These bodies are rendered better driers by boiling them with a small quantity of sugar of lead. Linseed oil is frequently of a bright green colour, which in some cases may be got rid of by boiling the oil with some fresh animal charcoal, skimming off the mucilage and other impurities, which rise to the surface, and afterwards filtering it, while warm, through blotting paper or flannel.

SOAP.

This compound consists of oil, alkali and water, as its original compounds, but very important alterations take place when made to unite.

The process of manufacturing soap consists in boiling a solution of caustic soda with oil; the two combine together, and the whole is kept boiling, until it is thought by the workmen that by cooling it will solidify; it is then baled out into wooden boxes, and when cold, cut into squares. The chemical change above alluded to will be noticed under the article Animal Products.

VOLATILE OILS.

These oils are obtained from various parts of the plant, as the seeds, flowers, roots and wood, gums and balsams. They are generally obtained by distillation, even when expression would suffice, in order to get rid of other vegetable matter, which would tend to render them impure and ropy.

These oils generally possess very strong odours, peculiar to the plant from which they are obtained. A very small portion of them is soluble in water; they may, however, be made to combine in some measure with water, sufficient to communicate their peculiar odour, by distilling the oil with a large quantity of water, or by making a paste of the oil and magnesia, and filtering the water through the mass.

thus formed. Most of them dissolve readily in alcohol, forming essences or spirits. They are not unfrequently adulterated with alcohol, diluting them in strength, and by fixed oils; the latter fraud is easily detected, by their leaving a greasy spot on paper when volatilized.

These oils are highly inflammable, and during combustion produce water and carbonic acid gas.

By long keeping or exposure to the air, they are converted into substances of a resinous nature, and at the same time lose much of their odorous properties.

OIL OF TURPENTINE

Is obtained by distilling the common turpentine in iron retorts. A clear, highly inflammable and volatile fluid, called spirits of turpentine, comes over, leaving in the retort the resin. It is usual to add water with the turpentine, previous to distilling it, to prevent the too rapid action of the fire, by which it would become burnt. Turpentine thus prepared is said to combine with a small quantity of the water, in which case it is very unfit for the painter. It differs from most of the essential oils in not being soluble in alcohol.

These oils, like the preceding, consist of carbon, hydrogen and oxygen.

CAMPHOR

Is the produce of the *Laurus camphora*. The London market is principally supplied with that obtained from Japan. It differs from the essential oils in always remaining concrete at common temperatures. It is, however, easily volatilized, and is very inflammable. It is readily dissolved by alcohol and the oils, but is very sparingly soluble in water.

By repeated distillation with some absorbent substance, it is converted into a liquid, possessing the general character of the essential oils.

By distilling Camphor along with nitric acid, in a glass retort, it is converted into an acid, called Camphoric, which can be made to combine with the salifiable bases, forming a class of salts termed Camphorates.

An artificial camphor has been obtained by passing a stream of muriatic acid gas through spirits of turpentine. A deposition takes place of a substance resembling camphor in many respects, but of no value whatever in the arts.

Camphor, by being resolved into its ultimate elements, affords in 100 parts:—

Carbon	78.02
Hydrogen	11.58
Oxygen	10.40
	100.

RESINS AND BALSAMS.

Resins may be divided into Resins Proper, such as common resin of turpentine, copal, juniper or sandrach, mastic, &c.; Gum Resins, consisting of a compound of gum and resin, as gamboge, ammoniacum, assafoetida, and olibanum; and Balsams, consisting of resins and essential oils, as balsam of tolu, of copaiba, &c.

RESINS PROPER.

The common resin or rosin, may be taken as a specimen of this class. It is a dry, hard, brittle substance, breaking with a glassy fracture, quite insoluble in water, but soluble in alcohol, from which it is again precipitated by the addition of water. It burns readily, giving out a large quantity of carbon, charcoal, or soot, in a state of minute division; this on being collected, forms the common lamp black. It melts at a temperature a little above boiling water, and becomes hard again on cooling, forming a resin commonly called Colophony.

By destructive distillation it is said to afford, in 100 parts:

Carbon	75.00
Oxygen	12.50
Hydrogen	12.50
	100.

MASTIC

Is supposed to have received its name from the circumstance of it being commonly chewed by the Turks and Greeks, derived from *masticare*. It is the produce of the *Pistacia Lentiscus*. It is obtained principally from Scio, in the form of drops or tears. It is extensively employed in the preparation of varnish.

SANDARACH

Was formerly supposed to be the produce of the *Juniperus Communis*, and was therefore called Gum Juniper. It is now, however, proved to be the produce of a species of *Thuia*, or *Arbor Vitæ*. It is mixed with some other in the preparation of varnish, but is seldom employed alone. The tree from which it is obtained is a native of Morocco, from which place the principal supply is derived.

DRAGON'S BLOOD

Is a resin, the produce of a tree growing in Africa, Asia, and America, called the *Pterocarpus Draco*. It is of a dark red colour, becoming brighter when pulverised; it is soluble in alcohol, but not in water. It has occasionally been employed as a pigment, but with little success.

COPAL

Is a hard transparent resin of a pale yellow colour, obtained from the tree *Copallinum*, a native of North America. It seems to hold a middle place between the resins and amber; like them it dissolves in the fixed oils, but it is dissolved by alcohol with some difficulty. It forms with oil and turpentine a valuable varnish, and by the aid of camphor is made to dissolve in alcohol, forming a hard spirit varnish. A piece of copal suspended in the vapour of alcohol gradually melts, and falls into the spirits by drops, and is then dissolved with facility.

Camphor, when triturated with copal, renders it more soluble in spirit.

BENZOIN, OR BENJAMIN,

Is a resin, the product of a tree growing in Siam and

Sumatra, the *Styrax Benzoin*. It contains an acid of a fragrant smell, called benzoic acid. This is readily obtained by reducing the resin to powder, and heating it on an iron plate, over which a cone of paper must be placed to receive the fumes; these are then condensed, and adhere to the paper in a beautiful crystalline form.

Several other resins furnish this acid, as the *styrax*, *tolu*, and *Peru*.

ELEMI

Is a scarce resin, imported into this country, in the form of cylindrical cakes, covered with palm leaves. It is said to be the produce of a species of *amyris* growing in the West Indies. It is but little used in the arts.

ANIMI.

This resin is imported both from Asia and America; it is said to form an excellent varnish, and is largely employed for that purpose in the arts.

VARNISHES

Are solutions of the above resins, either in alcohol or oil. In the preparation of the various varnishes each manufacturer has some form peculiar to his own process, which he flatters himself is superior to that of any other. These compounds pass under a variety of names, depending generally on the articles employed in their formation; as *amber*, *copal*, *mastic*, *oil* and *spirit*, *soft* and *hard*, varnishes. The spirit varnishes are composed of the following resins, varying in quantity and number, according to their fancied superiority by the manufacturer. The resins are by the latter generally denominated gums; hence they are called *gum sandarach*, *mastic*, *shell* and *seed lac*, *animi* and *elemi*; to which is sometimes added *Venice turpentine* and *spirits of turpentine*, to prevent their cracking. The whole of these are seldom employed at one time, some rejecting one resin, others another, and the quantity of each varying also with almost every manufacturer.

The following forms are not given with any view of their

superiority over those now employed, but merely to convey an idea of the mode employed in their manufacture; at the same time, I have every reason to believe them to be very excellent varnishes.

AMBER VARNISH.

Take half a pound of amber, and place it in a clean iron pot, closely covered, leaving a small hole in the lid, on a clear charcoal fire, until the amber begins to melt or agglutinate; it must then be removed, and suffered to cool a little; add a pound of the best painter's varnish, when the whole must be made to boil, keeping the mixture well stirred; again permit it to cool, and add to it a pound of spirits of turpentine, incorporate the whole well together; if too thick, a little more turpentine may be added. This varnish is always of a brown colour, owing to the amber being slightly burnt during the process.

MASTIC VARNISH.

Take 12 oz. of mastic, well cleaned from impurities, $\frac{1}{2}$ oz. of camphor, $1\frac{1}{2}$ oz. of Venice turpentine, 5 oz. of pounded glass (this substance acts mechanically only, not being in any way re-acted upon), and oil of turpentine, prepared without water, 36 oz. Mix together the resin, camphor, Venice turpentine, and glass, with only sufficient oil of turpentine to cover the whole; these must be kept constantly stirred, in a vessel surrounded with boiling water, until the whole is well incorporated; then add the remaining turpentine, and continue the process at a moderate heat, until the whole is dissolved; when this is effected, strain it through muslin while warm, and remove it to a cool place, to allow the grosser particles to subside. The clear liquor may then be poured from the sediment at the bottom, and preserved in bottles closely corked. The above is said to form a very excellent varnish for the artist.

In a paper read some years back by Mr. Sheldrake, before the Society of Arts, several useful hints to the artist will be found relative to vehicles and varnishes. In it is recommended

a solution of amber or copal, as the only vehicle that should be employed, and I think with great propriety; for these substances in drying merely give out the liquid, by which they were rendered soluble; but with oils, or compounds of them, they form a pellicle, and at the same time absorb oxygen from the atmosphere; again, the amber and copal not being soluble in the various menstrua effecting the former, are less liable to injury in the process of cleaning—and his paper further states, that solutions of these substances do not, like oils, become discoloured by being deprived of light and air; hence, if such be correct, the great superiority over those vehicles now employed, more particularly that compound termed Gumtion, and Macgilp.

MACGILP, &c.

These compounds, generally disapproved of by all, are yet employed by most artists, and are usually prepared by mixing equal parts of drying oil and mastic varnish.

Their use in the present day, with the full conviction of their impropriety, offers one of those lamentable instances, so common to be met with, of still rigidly adhering to the old method, rather than adopt any improvement that may be discovered; and can only be accounted for by a blind and misguided prejudice. At the same time, the free use of any new compound offered, not having the undeniable test of experience, is not here recommended; but in this macgilp, so generally employed, we have one obviously bad, and any change must be for the better.

Mr. Hammond Jones lately received the gold Isis medal for an improved vehicle for water colour painting, consisting of a solution of borax and gum tragacanth, but which I believe has not been much employed.

The reader will find this subject amply examined in Field's work before quoted.

The author has frequently been applied to by artists, for an explanation of the cause, and the method of preventing, during the process of varnishing, that distressing result

technically termed chilling; by which the varnish becomes covered with a kind of bloom, or mildew, totally destroying, so long as it is allowed to continue, the appearance of the painting.

I am disposed to think it is caused by the hygrometric moisture, always more or less present in the atmosphere, which being deposited on the wet varnish, prevents the due arrangement of the atoms of the resin, so as to interfere with the free transmission of the rays of light through them; for it is evident these atoms do arrange themselves in one particular position, and this being destroyed by the interposition of the atoms of water adhering to the canvass, interferes with this arrangement—to obviate which, paintings should always be varnished in a room the temperature of which during the process, and until the varnish is dry, should never be lower than 60° Fahr.

GUM RESINS.

GAMBOGE is obtained from the stalagmitis gambogoides, growing in Ceylon, Cochin China, and Spain; it is usually in the form of rounded masses or rolls, it has no smell, and but little taste; it leaves however a very peculiar and nauseous feeling in the throat, and possesses in doses of 5 to 10 grains violent purgative qualities. Gamboge is not soluble in water; but owing to the quantity of gum which it contains, is extremely miscible. Alcohol is the true solvent, with which it forms a deep golden coloured solution, from which the colouring matter may be precipitated by the addition of water. The precipitate thus formed, has been introduced as a pigment, under the name of Extract of Gamboge, but with what success I cannot say. It may improve it as an oil pigment, but cannot add to its qualities in water colour painting; it is not a very permanent body in any form.

FRANKINCENSE, AND OLIBANUM,

Are obtained from two trees of the same class, (*Juniperus lycia*); although from two distinct trees, their pro-

perties so closely resemble each other, as often to lead to their being considered the same; their use is principally confined to the medical practitioner.

AMMONIACUM.

This gum resin is employed only in medicine, and is imported into this country from Africa. It is usually in the form of tears, possessing a faint smell, and a sweet but nauseous taste.

ASSAFÆTIDA

Is obtained from Persia, and like the preceding is employed principally as a medicinal substance. It is usually in masses, possessing a strong disagreeable fetid odour, and subacrid taste.

MYRRH

Is said to be the product of a tree growing in Ethiopia and Arabia, but little is known of the plant itself. The gum resin is usually in the form of small masses and tears.

BALSAMS.

The principal of this class are those of Tolu and Peru, their use is entirely restricted to the medical practitioner; they both contain Benzoic Acid (which see).

BITUMENS, COAL, &c.

Bitumens are closely allied to the resins and oils in many of their properties; they are generally supposed to be the fossil remains of vegetables. Their general analysis affords Carbon, Hydrogen, and Oxygen. Some of them, however, are composed of the two former only, as

NAPTHA,

A fluid of a yellowish white colour, very combustible, possessing a powerful odour; it is lighter than water, and takes fire as rapidly as spirits. It is found on the shores of the Caspian sea, in Sicily, and Italy. It is principally employed for lamps, being cheaper than spirits in the laboratory. It affords more heat but less light than oil. A

fluid differing a little from the above is obtained from the distillation of coal in the gas houses; the former is, however, purer, and less disagreeable in smell. By a recent analysis pure naptha consists of

Carbon	87.21
Hydrogen	12.79

In 100 .. parts

The resins, &c. dissolve freely in this liquid, and it might be made use of for that purpose, when the disagreeable smell is not an object.

ASPHALTUM.

This substance is not unfrequently called jew's pitch. It is a smooth, hard, brittle, black or brown substance, when broken it presents a polished surface; and is found floating on the surface of the Asphaltic lake in India, called the Dead Sea, and in many other parts of the globe, particularly in the islands of Barbadoes and Trinidad, in the West Indies. It consists chiefly of bituminous oil, hydrogen, and charcoal.

It was employed by the ancients as mortar for building, and also by the Egyptians for the embalming of bodies—the bitumen now found attached to mummies forms a pigment called mummy colour.

Asphaltum is sometimes employed as a brown pigment, but it is said in drying to contract very much, causing it to crack. It dissolves freely in naptha, forming a varnish of deep brown colour.

COALS.

This important class of mineral compounds, are supposed at one time to have been vegetables, or the remains of immense forests, which by certain organic changes have been converted into their present state. They are divided into several classes, but agree in their general properties. During their distillation to obtain the coal gas, large quantities of nitrogen are given out; the presence of this element,

so peculiar to the animal kingdom is difficult to account for, and still remains a matter of doubt. Coals frequently contain the yellow iron pyrites, a compound of iron and sulphur.

Jet is a hard compact species of pitch coal, capable of receiving a fine polish ; it differs but little from the preceding, except in structure.

AMBER.

The true nature and origin of amber is still involved in doubt. It is generally considered to be a fossil resin, and is found on the shores of the Baltic, of Sicily, and the Adriatic Sea. It becomes powerfully electric when rubbed ; is usually obtained in nodules, or roundish masses, of various sizes ; when fractured it presents a smooth or glassy surface.

It affords by combustion similar products to the preceding bodies, and its solution a durable varnish.

VEGETABLE ACIDS.

The principal of this class of compounds are the

Tartaric Acid.

Oxalic ditto.

Citric ditto.

Malic ditto.

Gallic ditto.

These acids are not generated during the decomposition of the vegetable furnishing them, as in one or two others to be mentioned, but are found ready formed, in the plants producing them.

TARTARIC ACID

Constitutes the sour principle of many vegetables, it is, however, generally obtained by decomposing the impure tartar found adhering to the casks during the process of wine making. This substance consists of the tartaric acid and potass: the former being in excess, it is called the bitartarate of potass, and when purified, forms the cream of tartar of the shops. To obtain the acid, this latter compound is mixed with chalk, and thrown in boiling water ; a decomposition takes place, the Tartaric Acid combines with the lime,

forming an insoluble tartrate of lime, which is again decomposed by sulphuric acid, and the Tartaric Acid separated by crystallization.

The elements of Tartaric Acid are, in 100 parts—

Carbon	36.86
Hydrogen	60.61
Oxygen	3.03
	100.

The combinations of this acid are denominated Tartrates.

One of the most important of the combinations of this acid, in a medicinal point, is the Tartar Emetic, which is a compound of this acid, potass, and the protoxide of antimony, hence called Tartrate of Antimony and Potass.

OXALIC ACID.

The composition of this acid has already been noticed under the article carbon. As a vegetable product, it is found abundantly in the juice of the *Oxalis Acetosella*, or wood sorrel, combined with potass; and as in the previous case, this acid being in excess, it is called the bin-oxalate of potass, or the salt of sorrel of the shops. The artificial preparation has been before given (see Carbon). It is a virulent poison, the successful antidote of which is chalk and water, the acid combining with the lime, forms an insoluble oxalate of lime. Oxalic acid combines with the salifiable bases, forming a class of salts denominated Oxalates.

CITRIC ACID.

This acid exists ready formed in the lemon and lime. It may be obtained by a process similar to that described for tartaric acid. It forms large crystals, in which state it should always be purchased, being, when in powder, liable to be adulterated with the tartaric acid. It is occasionally employed by the dyers in an impure state, and when purified forms, with carbonate of soda, an agreeable effervescing draught. The combinations of this acid with a base, are termed Citrates.

MALIC ACID

Is obtained from the juice of the apple, and is sometimes the cause of the deleterious properties of cyder, by its dissolving the lead of the press in which the apples are expressed, in the process of making cyder, forming a malate of lead, a compound of a highly poisonous character.

This acid is not confined to the apple, being present in many other fruits. Its combinations are termed Malates.

GALLIC ACID

Is obtained chiefly from the nut-galls; these are excrescences growing on the oak, caused by the puncture of an insect. The acid may be obtained by exposing to the atmosphere an infusion of galls. It forms, by its union with the persalts of iron, a black compound, or the basis of common ink, which is a gallate of the peroxide of iron. Its combinations are termed Gallates.

An infusion of galls is frequently employed in the process of analysis, for the detection of metallic oxides, with many of which the Gallic Acid combines, forming insoluble precipitates, indicating by the colour the nature of the oxide.

The following acids may be obtained from the several substances affixed to them, but they are of little importance in the arts—

MECONIC ACID—Opium.

MOROXYLIC ACID—White mulberry tree.

PECTIC ACID—From carrots, &c.

LACTIC ACID—Beet root, milk.

SUBERIC ACID—Cork.

KINIC ACID—Peruvian bark.

&c. &c.

VEGETABLE ALKALIES.

The various proximate principles under this name, are termed Alkaline, from the property they possess of combining with and neutralizing the acids, giving rise to a class of salts, bearing the peculiar character of the vegetables from which

they were obtained; with respect to their action on the human body, it is precisely the same as the plant from which they are obtained, but in a more powerful degree, the other compounds of the vegetables being removed—they are sometimes called the active principle. With few exceptions, they all contain nitrogen, an element but seldom found to form part of the components of vegetable bodies. Their use, at present, is confined to medicine only, and from their general character, and the expence attending their extrication from other vegetable matter composing the plant, it does not appear probable that any other use can be made of them. The principal are

QUININA }
CINCHONIA } From the Peruvian bark.

MORPHIA }
NARCOTINE } From opium.

DIGITALIA—From the digitalis purpurea.

BRUCIA—From the brucia autodissentea.

VERATRIA—From the veratrino sabadilla, &c.

STRYNIA—From the nux vomica.

&c. &c.

FERMENTATION

Is generally divided into three states; these are distinguished by the terms Vinous, signifying the formation of spirit, or an intoxicating liquor; Acetous, as illustrated by the formation of vinegar; and Putrefactive, or an entire decomposition.

VINOUS FERMENTATION.

Before this change in any of the vegetable juices can be effected, saccharine matter must be present: thus, if one part of sugar and five of water be mixed with a little yeast, the following change takes place, provided a temperature of not more than 80°, or less than 60°, be maintained.

The mixture will become thick or muddy, and bubbles of air rise to the surface of the liquid, which are carbonic acid gas. The mixture is no longer sweet, but if submitted to

the process of distillation, will afford an intoxicating liquor, or spirit. It has been ascertained, that the sugar is the only substance acted upon, which, as before stated, is a compound of hydrogen, carbon, and oxygen; and so is alcohol, or pure spirit; but in the latter, these elements, as noticed in Starch, differ only in their relative quantities.

The intoxicating properties of all fermented liquors are owing entirely to the alcohol, which is the same in all, but modified in taste, by the presence of some essential oil.

Pure alcohol consists of,

Carbon	49.10
Hydrogen	14.09
Oxygen.....	36.81

In 100. parts.

It is a colourless transparent liquid, highly inflammable, and, if pure, burns away without leaving any residue. No degree of cold yet produced, is capable of freezing it. It boils at a temperature of 173° ; its boiling point is, however, greatly modified by its absolute weight, or specific gravity, and of course its strength also, the lightest being the strongest.

ETHERS.

These interesting compounds are formed by the action of the mineral acids on pure alcohol. Being distinguished by the acid employed; thus we have Sulphuric, Nitric, and Muriatic Ethers. Like the preceding, they are compounds of carbon, hydrogen, and oxygen. When purified they are colourless fluids, much lighter than alcohol, and differ materially from it in not mixing with water; volatilizing at a low temperature, and under the receiver of an air pump are entirely volatilized in the form of vapour, at a temperature considerably below the freezing point of water.

ACETOUS FERMENTATION.

When vegetable juices, having undergone the vinous fermentation, are exposed for some time to the atmosphere,

the alcohol, or spirit, disappears, and the liquor becomes converted into an acid. This change is called the **Acetous Fermentation**, from the fact of vinegar, or acetic acid, being the product. During the process, oxygen gas is absorbed, which uniting with a portion of the carbon of the alcohol, is liberated in the form of carbonic acid gas. The impure acid thus formed, if submitted to the process of distillation, affords a colourless transparent liquid, of the peculiar odour of vinegar. It readily inflames, and if applied to the skin, excoriates and blisters it. It combines with the salifiable bases, forming a class of salts, called **Acetates**, as the verdigris, or acetate of copper; and sugar of lead, or the acetate of lead. Pure acetic acid is a compound of the three elements, carbon, oxygen, and hydrogen.

Acetic Acid may be obtained by the distillation of green wood, as before mentioned.

PUTREFACTIVE FERMENTATION.

This chemical change which takes place in all organized bodies deprived of life when exposed to the action of the air and moisture, although so common, is yet but imperfectly understood. This much we know, that the elements entering into the composition of the body, are during the process liberated by the decomposition. These, generally, at the moment of their liberation reunite, forming new compounds.

ANIMAL CHEMISTRY.

Animal Chemistry relates to the chemical examination of the various products obtained from animal matter.

Animal substances, like those of the vegetable kingdom, present several proximate principles, consisting of the elements carbon, oxygen, hydrogen, and nitrogen, the latter element being more frequently present, and in greater quantity, than those of the former class. This element is said to induce, in animal matters, a proneness to decomposition, during which change, the alkali ammonia is always produced, by the union of this element with a portion of the hydrogen. See Ammonia.

When animal matters are exposed to the action of the atmosphere in a humid state, at any temperature above that which would convert the liquids into solids by freezing, decomposition rapidly ensues; the several elements composing the mass are liberated, and at the moment of their liberation, unite together in different proportions, forming new compounds.

Several substances, by combining with animal matter, prevent this decomposition, hence they are called anti-putrefactives, the principal of which are common salt, alcohol, vinegar, charcoal, sugar, creosote, &c. &c.

The proximate principles of the animal kingdom are numerous, and will be examined as they occur, under the various matters affording them. The more obvious and better known properties of the various substances constituting the animal structure, may be enumerated under the following heads:—

Bones and Teeth.

Muscle.

Cartilage.

Fat.

Skin.

Blood, Urine, and other liquids.

Shell, Horn, Hair, and Feathers.

Colouring matter.

We therefore propose to examine these several compounds, as constituting the structure of the animal kingdom.

BONE.

The solid frame work of man and other quadrupeds, consists principally of the phosphate and carbonate of lime; this is rendered more compact and solid by an admixture of gelatine and cartilage—they also contain fat or marrow.

The gelatinous part of bones may be obtained by boiling them for some time in water, which on cooling forms a gelatinous mass or jelly.

This substance may also be obtained from skin, ligaments, membranes, and tendons. It exists in a very pure state in the membrane forming the sounds of the sturgeon and other fish, as the isinglass. Glue is an example of the same substance in an impure state.

The characteristic property of gelatine, is in its union with tannin, forming what is sometimes called tanno-gelatine, better known as leather. These two substances, therefore, form a test for each other.

Cartilage is readily obtained from bones, by digesting them in diluted muriatic acid; the gelatine and earthy parts are thus dissolved, leaving the cartilage in the original form of the bone, which if dried resembles horn.

Bones by analysis afford about 38 per cent of animal matter, and 67 of earthy salts.

The earthy matter consists principally of the phosphate of lime, (which is a combination of the phosphoric acid and lime). 100 parts of bone furnish, by analysis, the following substances:

Gelatine and Cartilage ..	32.17
Blood Vessels.....	1.13
Fluoride of Calcium	2. 0
Phosphate of Lime	51.04
Carbonate ditto	11.30
Phosphate Magnesia	1.16
Ditto of Soda, Muriate of	
Soda, and Water	1.20

 100.
IVORY BLACK.

The preparation known under this name is prepared by calcining bones in a covered vessel, by which means a considerable portion of the charcoal of the animal matter remains mixed with the bones; this, when pulverized, forms the pigment above named; which, if submitted to heat, is converted into a white mass, called bone ashes, consisting of the various earthy and saline compounds before mentioned.

TEETH

Differ from bones in a very slight degree, the enamel consists principally of phosphate of lime, and gelatine, without cartilage; the interior being of the same composition as the bones generally.

MUSCLE.

The muscles or fleshy part of animals consist principally of fibrin, albumen, gelatine, osmazome, fatty and saline matter, &c.

Of these we shall examine osmazome only, albumen and fibrin will be examined under the article blood.

OSMAZOME

Is obtained by digesting raw muscle, (as pieces of lean beef) in water, and evaporating the solution thus obtained, until it becomes of the consistence of syrup; alcohol is then added, which dissolves the osmazome only, from which it may be obtained by evaporating the alcohol.

The substance thus obtained is supposed to give to soups and stews their peculiar flavour.

CARTILAGE (see Bone).

FAT.

This important animal product has lately been the subject of much chemical investigation. Animal fat may be said to exist in three states, as tallow, lard, and oil. It floats, and is insoluble in water; and when burned, gives out carbonic acid gas, and water; decomposed at a red heat in close vessels, it affords olefiant gas, and charcoal.

Chevreul and Braconnot are the chemists above referred to, as having discovered that animal fat is not, as it was formerly supposed, a distinct proximate principle, but is a compound of several, to which the names elain, margarine, and stearine, have been given (see vegetable fixed oils).

These principles may be obtained by boiling lard in alcohol; when the latter is allowed to cool, it separates into two substances, one of which remains fluid, and the other falls down to the bottom in the form of small crystalline grains: the latter is the stearine, and the former the elain. The stearine, when obtained from the vegetable fixed oils, is sometimes denominated margarine. It seems to be only a variety of stearine, and much ambiguity exists with respect to the misuse of the two names, if the compounds are not identical.

The soaps of this country generally contain animal fat, to give them solidity. Soap, as before stated, (see fixed oils) is a compound of the vegetable fixed oils and an alkali. The soaps formed by potass are generally soft, as the common soft soap, while those with soda form hard soaps. Hard water, or water containing lime, and also acids, decompose soap. The sulphate of lime is usually found in spring or hard water, together with the carbonate of the same earth, the acid of which unites with the alkalies of the soap, and the lime, combines with the components of the fat;

which, during the process of manufacturing the soap, is said to be converted into three acids, called the margaric, stearic, and oleic.

SPERMACETI

Is obtained from the spermaceti whale; it is a hard but brittle substance, and if repeatedly distilled, is entirely converted into a liquid oil. It unites with potass, forming a soap.

AMBERGRIS

Is supposed to be a concretion produced in the intestines of the above whale. It is found floating on the coasts of Africa and India, and consists of a peculiar fatty principle called ambreine.

ADIPOCERE.

This substance is obtained by submitting animal muscle to a constant stream of running water; in process of time it becomes converted into a kind of fatty matter, called adipocere, resembling in some of its properties spermaceti. The same substance is also produced, when animal matters are buried in large masses in the earth, so as to seclude the action of the atmosphere.

SKIN is principally composed of Gelatine, which see.

BLOOD.

If fresh drawn blood be examined by the microscope, it will be found to consist of a transparent fluid, in which minute globules of a red colour are floating; this quickly becomes converted into a jelly like mass, by which change, the fluid and the globules may be easily separated, the latter only, forming the natural coagulum, the thin fluid still retaining its primitive state; this change is called the coagulation, the cause of which is quite unknown.

The clot, or coagulated portion, is called the crassamentum, and the fluid the serum.

The crassamentum consists principally of fibrin, and the colouring matter of the blood; the latter may be separated

by washing the clot in water, the fibrin remaining in the form of a white fibrous mass.

FIBRIN

Is solid, tasteless, and inodorous, and by drying is rendered hard and brittle, forming with acetic acid, a gelatinous mass, and with nitric acid, a peculiar compound of a yellow colour. With sulphuric acid it forms a white matter, called Leucine. The colouring matter of the blood is supposed to be a distinct animal matter, called Hæmatosyn.

SERUM.

The serum of the blood is composed principally of Albumen, the characteristic property of which is its coagulation by heat, being converted into a substance resembling the coagulated white of egg, which is also albumen. The galvanic battery and acids act in the same manner.

It is this property of albumen which enables it to clarify syrup, &c., as in the process of sugar refining, the blood or albumen being mixed with the former, coagulates by heat, and thereby surrounds and fixes with it the suspended particles, which may then be removed together. Albumen, by destructive distillation, furnishes in 100 parts,

Carbon	50.00
Oxygen	26.67
Hydrogen	7.78
Nitrogen	15.58
	100.

URINE.

When urine is evaporated to the consistence of a syrup, it usually contains urea, and an acid mixed with other salts, called uric or lithic acid; this, by rather a complicated process, may be obtained, free from the other matters. It is usually of a brownish grey colour, tasteless, and inodorous; besides which acid, urine sometimes contains two other acids, called purpuric and rosaic acids, together with lactic

acid, and several lactates, phosphates of soda and ammonia, muriate of soda, and other salts, varying in number and quantity, in almost every specimen. The characteristic principle obtained from urine is the compound urea.

INDIAN YELLOW

Is a bright yellow pigment obtained from the urine of the camel; its composition varies, but the principal constituents are the uric, or lithic acid, phosphoric acid, and lime, and occasionally muriate of ammonia. Experience has proved it to be by no means a permanent colour, and from the nature of its composition it does not appear that it ever can be successfully employed; its price also is very high. Field's True Platina Yellow is said to be a good substitute, and of considerable more permanency.

BILE

Is a viscid unctuous liquid, of a greenish yellow colour and foetid odour, being a secretion formed in the liver; its taste is intensely bitter, and rather sweet.

Of the component parts of liquid bile, water forms seven-eighths of the whole, the remaining part consists of several alkaline salts, phosphate of lime, a peculiar bitter animal resin, yellow matter, picromel, and albumen.

BILE, OR GALL,

Is employed in several processes of the arts, from the property it has of combining with fatty matter or grease, forming a saponaceous mass; and by the artist to remove the grease from paper, or, as it is termed, to cause the colours to flow. In the former case it is usually employed as it is obtained from the animal, but for the latter it requires some preparation; hence called

PREPARED GALL;

The common method of preparing it is simply to strain the grosser parts from the gall, as it comes from the animal, and afterwards evaporating to the consistence of a thick syrup; it is then distributed into small pots, and will

remain free from putridity for years. The gall thus prepared always contains the yellow colouring matter, so peculiar to itself, and therefore cannot be employed with many delicate tints; it frequently contains free alkali, and is therefore destructive to the vegetable colours. To obviate this inconvenience, an improved colourless gall was invented, in which it is said all that is valuable to the artist is retained, and that which is detrimental rejected. The following is the process for manufacturing it, as given by the inventor:—To a pint of ox-gall, boiled and skimmed, put one ounce of powdered alum; continue the boiling until it is dissolved; when cold, put it into a bottle and cork it close. To another pint of gall proceed in the same manner, substituting one ounce of common salt for the alum. The above preparations must then be allowed to stand in a warm room for three months, by which means, it is said, they deposit a thick sediment and become clear and of a pale yellow colour only. To remove the colour entirely, the two must then be mixed in equal proportions; a thick coagulum is thus formed, carrying with it the remaining colouring matter of the gall. The preparation thus obtained is said to possess all the valuable properties of the gall, with the superior advantage of being limpid and colourless; its general application and utility, however, I fear will not come up to the sanguine expectations of the inventor, for it is obvious that the gall thus obtained holds in solution two, if not three, saline bodies; these must necessarily act upon the pigments with which it is used, and (if it does not deprive them of colour) will materially affect their purity.

GALL STONE.

This is a peculiar concretion found in the gall bladder of animals, and occasionally that of the human subject. They are of two kinds, one of a fatty nature, said to resemble spermaceti, from which a peculiar animal principle has been obtained called cholestrine; the other consists chiefly of a

yellow insoluble matter, which is occasionally employed as a pigment; it is insoluble in water and alcohol, and resembles inspissated bile: it is not, however, a durable pigment.

The other animal fluids, although highly interesting, are not of sufficient importance to demand a separate examination.

LYMPH: is employed in the lubrication of the different cavities of the body, and is supplied by certain vessels called lymphatics. It varies in its properties, but resembles a weak solution of albumen. When a burning body or blister is applied to the skin, a bladder or vesicle is immediately formed, containing a limpid fluid, this is lymph; it also forms the fluid generated in dropsical patients.

SALIVA, or the fluid lubricating the mouth.

PANCREATIC JUICE, differing but little from the former.

TEARS, consisting of water, albumen, soda, and muriate of soda.

SYNOVIA, the lubricating fluid secreted in the joints.

PUS, or **MATTER.**

SHELL.

The shells of marine animals are composed principally of carbonate of lime, with a little phosphate of lime, and animal matter.

HORNS, NAILS, FEATHERS,

Consist principally of albumen, which see.

HAIR

Is also composed of a substance resembling dried albumen, and also gelatine. Two kinds of oil have been discovered in hair, one of which is white, and exists in all hair, and the other coloured, depending on the colour of the hair; red hair affording a yellow oil, and black hair one of a darker nature.

COCHINEAL.

This valuable insect, (the *coccus cacti* of Linnæus) is a native of South America. It is now produced in the West Indies, and lately by the French in their new colony, for-

merly Algiers. It was long supposed by the ancients to be the seed of some unknown plant. The female only affords the colouring matter, which when it has arrived at its full growth attaches itself to the leaf on which it feeds (the *cactus opuntia*). The insects are brushed off the plants previous to their depositing their eggs, and are then stifled by smoke, dried, and packed in bags for sale.

CARMINE

Is manufactured from the above insect by a process similar to that described under the article Madder. It is a beautiful pigment, but by no means permanent, fading rapidly by the action of the sun's rays, and when prepared with the oxide of tin, by sulphuretted hydrogen.

LAC.

This resinous substance, distinguished by the terms shell and seed, is the produce of an insect in the East Indies. The colouring matter of Lac was formerly much employed, its use is now principally confined to the dyer. The best is imported from India, under the names of Lac Lake and Lac Dye; the latter, which is the most valuable, is sometimes employed as a scarlet dye, but is far inferior to the cochineal.

CONCLUSION.

We have thus endeavoured to lay before the artist a brief sketch of the nature and properties of the most important bodies, both simple and compound, which in his professional occupation he is called upon to employ. In an elementary work it is impossible to give any lengthened description; but if we have succeeded in convincing the artist of the important

part which Chemistry performs, in connexion with the Fine Arts, we have achieved the point most to be desired—being convinced that when once that feeling is firmly established, it will lead to further inquiry and an improvement in many points of great importance.

Some disappointment may be felt in the absence of any practical information on the employment of the pigments. Should such be the case, it must be borne in mind that the author is a chemist and not an artist, and that all he professes to do, or is able to perform, is to explain the chemical properties and mode of manufacture of the pigments.

The author has very generally found a desire among artists to become acquainted with the properties of their pigments, and he trusts, in the absence of any other work of the kind, that this will afford them the required information.

ERRATA.

Page 8, line 12, *for is read are.*

— 87, — 17, *for disposes read dispose.*

— 122, — 1, *for aggluternises read agglutinates.*

— 122, — 20, *for deprives read deprive.*

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